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PRODUCT ENGINEERING

McGRAW-HILL WEEKLY FOR DESIGN ENGINEERS · APRIL 24, 1961

ENGINEER AND DESIGNER LOOK AT NY AUTO SHOW

pages 24 and 65

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LEAKTIGHT SEALS FOR HIGH PRESSURE .... Page 72
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McGRAW-HILL WEEKLY FOR DESIGN ENGINEERS

April 24, 1961 Vol. 32, No. 17

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How Nickel gets music out of solid rock

Deep in the Caverns of Luray in Virginia is one of the world's musical marvels—the famed "Stalacpipe" organ—a unique instrument that gets rare tonal beauty from age-old stalactites.

To get music out of solid rock, the stalactites have threaded metal rods bolted through them—close to small, wire-wound magnets. When an electronically-controlled hammer strikes a stalactite, the combination of rod and magnet becomes a tone generator whose impulses pass out through an amplifier.

Imagine the dampness of the Caverns . . . the rust-producing environment . . . and what could soon happen to these musical rods bolted through the rock. Here is where a metal has to really prove itself.

Nickel means trouble-free performance. To prevent excessive rust and resulting expansion that could easily crack or snap off the stalactites, a special electrical steel—a steel with Nickel in it—was chosen. This high nickel alloy steel—47-50% Nickel—stands up to the eternal dampness of this underground concert hall . . . and provides the exact combination of magnetic properties needed for low power requirements and full high fidelity.

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Big tone from little Nickel alloy rods. Pen shows the size of Allegheny Ludlum Steel Corporation's AL-4750 nickel alloy special steel rods bolted through ancient stalactites. The rods vibrate with the rock after being struck by rubber-tipped hammers.

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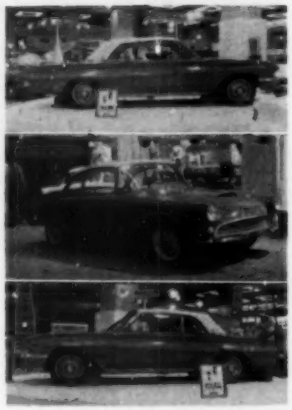
INTERESTING TO NOTE



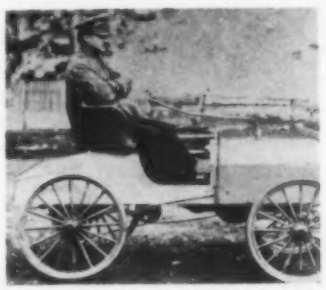
On our cover – industrial designer Albrecht Goertz, designer of the BMW 508 and several other European cars, attended New York's International Automobile Show and, together with our associate editor, Joseph J. Kelleher, has evaluated some of the highpoints, commencing on page 24. Each year the show seems to have more compact cars on display–the little demons have either been breeding during the winter or the popularity of the imports is greater than their declining sales figure would indicate.

The sales king, Volkswagen, was back again after choosing not to exhibit last year. Down the aisle, the queen of the imports, Rolls Royce, displayed its low-price model (a modest $15,000), and another listed at $26,000. As last year, a small SOLD sign appeared on both models, proving again that quality sells.

The Soviet Union, which last year brought over a rather heavy-handed copy of one of Detroit's poorer examples, elected to stay at home. Israel, on the other hand, made its debut as an auto-producing nation with its Sabra, a plastic-body sportster.

Among the other new models, Jaguar introduced its XK-E Roadster and coupe, said to be "the fastest production-type sports cars ever offered for public sale." They can reach speeds of 150 mph–just the thing for a Sunday drive in the country? Aside from being the star of the show with its new design, the car sold well (40 were ordered the first day). Daimler also introduced a new 2½-liter sports car, the SP 250. Although the show was predominantly foreign, Detroit was well represented–Chevy's Monza (named after Italy's famous race track), Ford's Galaxie and Buick's new Skylark, a 188-in. "sports coupe." There were more American cars in the show this year than ever before.

Recession or no, the general impression held by most exhibitors was that, for the first time, people were coming to the show with their minds made up to buy–it was only a question of choice. During the first hectic day, sales figures gave the auto people a rather optimistic picture. American Motors sold 25 cars; Mercedes, 5; and the popular Volkswagen, 65.



From those thousands of people milling about the show to see the newest cars on the road, let's now turn to pay tribute to one of America's auto pioneers, Robert E. Sheldon, the first man to build a car in Alaska. As a youth of

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21, he had never had a chance to see an automobile, yet Sheldon built his first gasoline-engine car in 1905 from pictures he had seen in newspapers and magazines. His motive was quite simple. He wanted to impress a young lady. She was being courted by a suitor who owned a fancy horse-drawn carriage. Sheldon powered his "car" with a 3½-hp marine engine he removed from a sunken boat and drove the rear wheels with two bicycle chains and sprockets. Because the car had a marine engine, it would run in either direction. To back up, he simply reversed the engine.

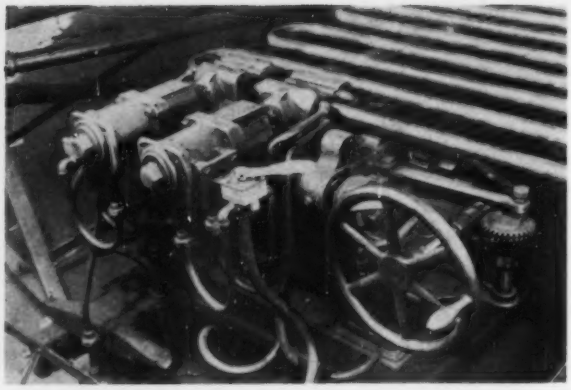
Not stopping his automotive career with the first Alaskan car, Sheldon felt the motor vehicle had a definite place in the Territory's transportation system. To prove it, in 1913 he quit his job with a Fairbanks electrical company and blazed a trail over a wagon path to Valdez, 370 miles away, in a new Detroit-made car. Two years later he formed a profitable automotive-stage company between Fairbanks and Valdez, cutting horse-and-wagon time by more than a third.

The motorized-stage route to Valdez has become Alaska's Route 1, a main part of the state's 2000-mile primary-road system.

Sheldon, now in his seventies, was a member of Alaska's first state legislature. As for his home-made car—it's still in running order, but has been retired to a museum at the University of Alaska.

Welder Won't Wear Out

It's always encouraging to see an old product retain its usefulness despite competition from clean, new counterparts. Recently we learned of a piece of resistance-welding equipment made in 1889 and used all these years to weld pipe coils for heating and refrigerating applications. The equipment, located at the Renipe Co, Chicago, was designed and manufactured by the Thomson Electric Welder Co, Lynn, Mass. It had some advanced



designs for its time, including individually operated work clamps activated by compressed air—something new in those days. (See photo above.)

For the most part, techniques for operating the machine have remained consistent over the years. Sections of black-iron pipe—in 1- or 2-inch diameters—are cleaned at the ends; edges are uniformly prepared and the section then put in the dies and clamped. Clamps are actuated through air valves. The right-hand platen is moved with a relatively large handwheel geared through a worm and ratchet. As is true with most hand-controlled machines, weld quality depends primarily on the operator's experience. Heats are determined by the color of the weldment—upset force is applied when the operator thinks the metal is about to flow. Renipe Co had the same man operating the machine for 52 years. Although he is now retired, the company occasionally calls him back to weld up some sections.

To cut production costs by reducing production time, designers have kept a sharp eye on new welding techniques. The article on page 76 gives some rules on designing for faster spotwelding. —Benedict A Leerburger Jr

NEXT WEEK IN PRODUCT ENGINEERING

. . . **Which Shock-absorbing System?**
A few guide calculations based on these efficiency factors and comparison table will simplify the choice.

. . . **New Random-access Memories for Digital Work**
Here are four new systems, tried and tested, but not yet on the market.

. . . **Designing Polycarbonate Parts**
As applications have grown, the do's and don'ts of design have been established. Here they are.

. . . **How to Set Tolerances for Selective Assembly**
Here's a graphical way to find the size of each group and a method for estimating the resulting fit.

. . . **Is Engineering the Sole Source for New-product Ideas?**
A noted industrial designer presents his point of view.

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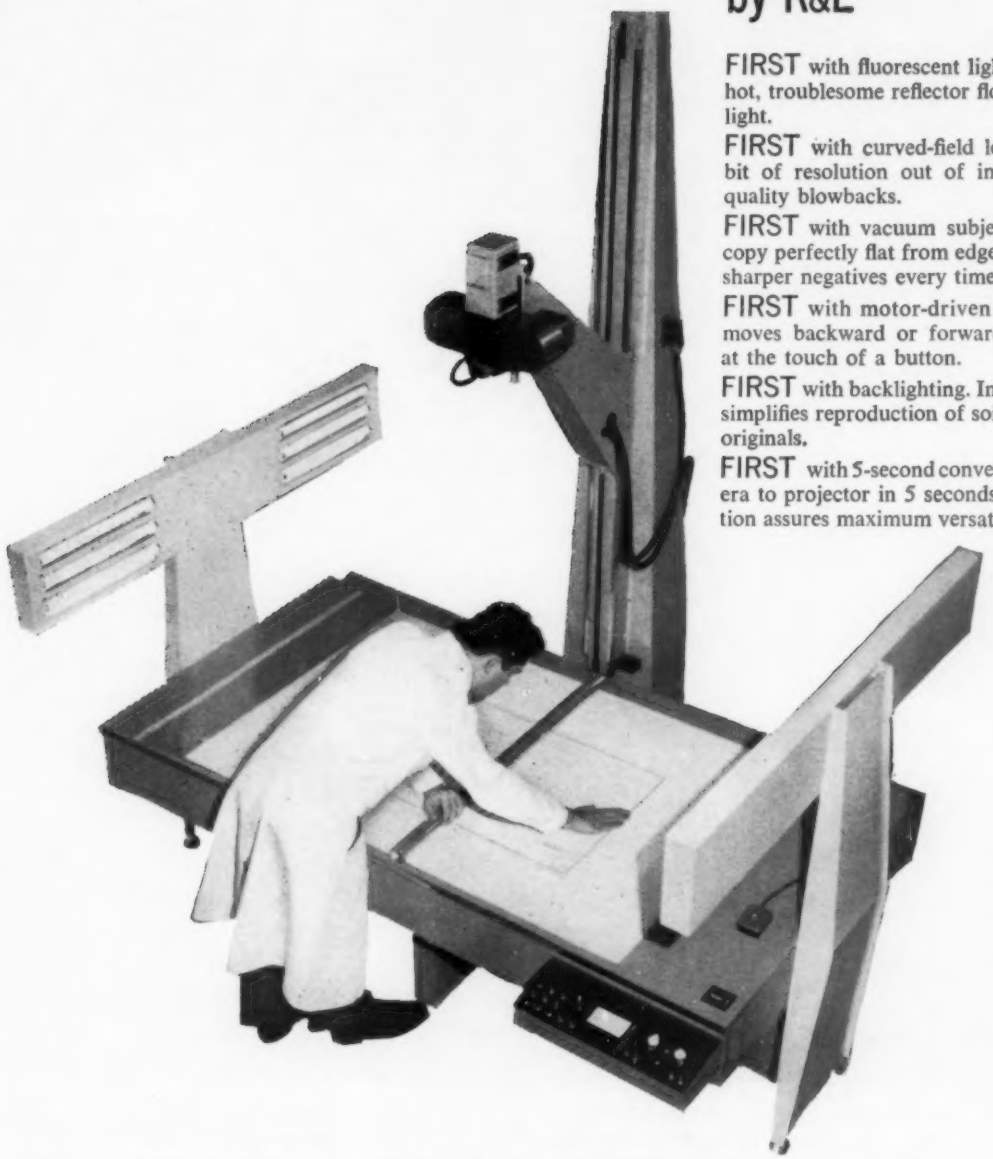

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WHAT'S HAPPENING IN RESEARCH...

Fluoroplastic bearings shine in no-lube tests

In unlubricated journal bearings, TFE (fluorocarbon) plastics outperformed graphite, resin-bonded systems, filled nylon, and several sintered oxides. In some cases, the load-speed performance of the Teflon-type materials was better than any of the others by a factor of as much as 30, F. F. Simpson of D Napier & Son Ltd, Acton, England, reported to the British Institution of Mechanical Engineers.

Among the materials tested were mixtures of TFE and bronze dust, sintered bronze impregnated with TFE and lead, TFE-carbon dust, wrapped bronze gauze impregnated with TFE, and TFE-lined steel. Bushings ($\frac{3}{8}$ in. bore, $\frac{7}{16}$ in. long) were run on mild-steel journals rotating at speeds from 25 to 12,000 rpm. Test time was 100 hr. Best performance was turned in by the first two combinations. They stood loads of 10,000 to 20,000 psi at speeds of 25,000 to 35,000 ft/min. for the 100-hr period. In contrast, plain carbon graphite bearings wore past the check point at loads of 2500 psi and speeds of 5000 ft/min. and mild steel seized at 50 psi and 100 ft/min.

Not all the TFE materials scored as high as the leaders. The TFE-carbon dust mixture, for instance, did little better than the carbon graphite and not as well as carbon-copper lead; and the TFE-bronze fabric combination was no better than resin-bonded fabrics (250 psi, 700 ft/min.)

Note: For data on another type of fluorocarbon bearing—reinforced TFE plus molydisulfide, see *PE*—Mar 20, p 76.

These metals are "safer" in liquid fluorine

Impact ignition of titanium and aluminum is less likely and less damaging in liquid fluorine than in liquid oxygen, C. J. Sterner of Air Products reports. The reason: Sterner theorizes that when titanium burns in oxygen, solid titanium dioxide forms and rapidly diffuses into the molten titanium, promoting and continuing the reaction. In fluorine, burning produces gases which serve as an insulating layer permitting the titanium to cool below the ignition temperature.

Aluminum is even less likely to ignite in liquid fluorine, probably owing to its thermal conductivity and formation of a fluoride coating.

Plated coatings for vibration damping?

Can plated coatings—chromium, cadmium, or lead—be used to reduce vibration of steel parts?

Soviet engineers have been testing such coatings and have come up with some surprising results. According to a CIA report, chromium plate, in thicknesses from 10 to 125 microns, was highly effective in increasing the damping of vibrations, and lead was least effective of the three. The tests were made on oil-hardened bearing steel, at both ambient and elevated (200 to 800 F) temperature. As might be expected, chromium is recommended for the upper range; while cadmium is probably the best all-round choice for normal-temperature use. A report appeared in *Vestnik mashinostroyeniya*, #12-60.

Pinpointing critical temperature

As benchmarks for temperature measurements, when the standard oxygen, water and sulfur temperatures can't be used, several new reference points are suggested by Canadian National Research Council (Ottawa). Among the suggested alternates are:

Freezing point of zinc (419.505 C) for boiling point of sulfur (444.6 C).

Argon triple point (−189.334 C), a slightly lower figure than its boiling point (see below) for the boiling point of oxygen (−182.97 C).

Freezing point of tin (231.913 C) for boiling point of sulfur (444.6 C).

That figure for oxygen, incidentally, is now a pretty firm one. At the AIP-ISA-NBS-symposium on temperature, C. H. von Dijk reported on a world-wide survey of the boiling points of oxygen, hydrogen, and helium and found surprisingly close agreement. His averages: 90.168 K for oxygen, 20.378 K for hydrogen and 4.215 K for helium.

Briefing the British record

Tensile strength of quartz fibers can be affected by moisture, R. B. King of Britain's Royal Aircraft Establishment reports. These supposedly inert and stable elements show a loss of as much as 26% in tensile strength at 100% relative humidity. Surprisingly, heating at 212 F and 392 F had no effect; and an increase in strain-rate nearly doubled strength of the fibers. Furthermore, the smaller fibers seemed much stronger than larger ones; an increase of 300% in strength was found for a decrease of 60 to 70% in diameter—in some cases, at least.

Fatigue data on Nimonic 90 under cyclic load at temperatures in the 1500 to 1650-F range is contained in a report by C. S. Landau of Britain's National Gas Turbine Establishment. He finds that cumulative strain varies much as creep does with number of cycles; and the total time to fracture is independent of the frequency, for low frequencies at least. Copies of the report are available on loan from Technical Information Div (BID) of NASA (the number is N-89324).

Brittle temperature of beryllium can be raised "several hundred degrees" by heat treatment, metallurgists at Britain's Atomic Weapon Research Establishment (Aldermaston) report. Long-term soaking at 1400 F seems to precipitate impurities without promoting grain growth, and produces parts that show considerable ductility well above 800 F.

Iron-tin alloys are under study at Tin Research Institute (Britain). The aim: to find out why those alloys frequently are brittle at room temperature and hot-short at elevated temperature. Recent findings indicate as little as 1% tin can cause trouble, though alloys with only 0.3% tin are fabricated without difficulty. The same appears true of steels with carbon contents of 0.6 and 1%. Up to 0.5% tin, they are ductile. Above 1%, they are not. Work is continuing, to find and explain the exact transition point. (Note: For news of another recent TRI report—on aluminum-tin bearings—see *PE*—Apr 3, p 6. —ARG

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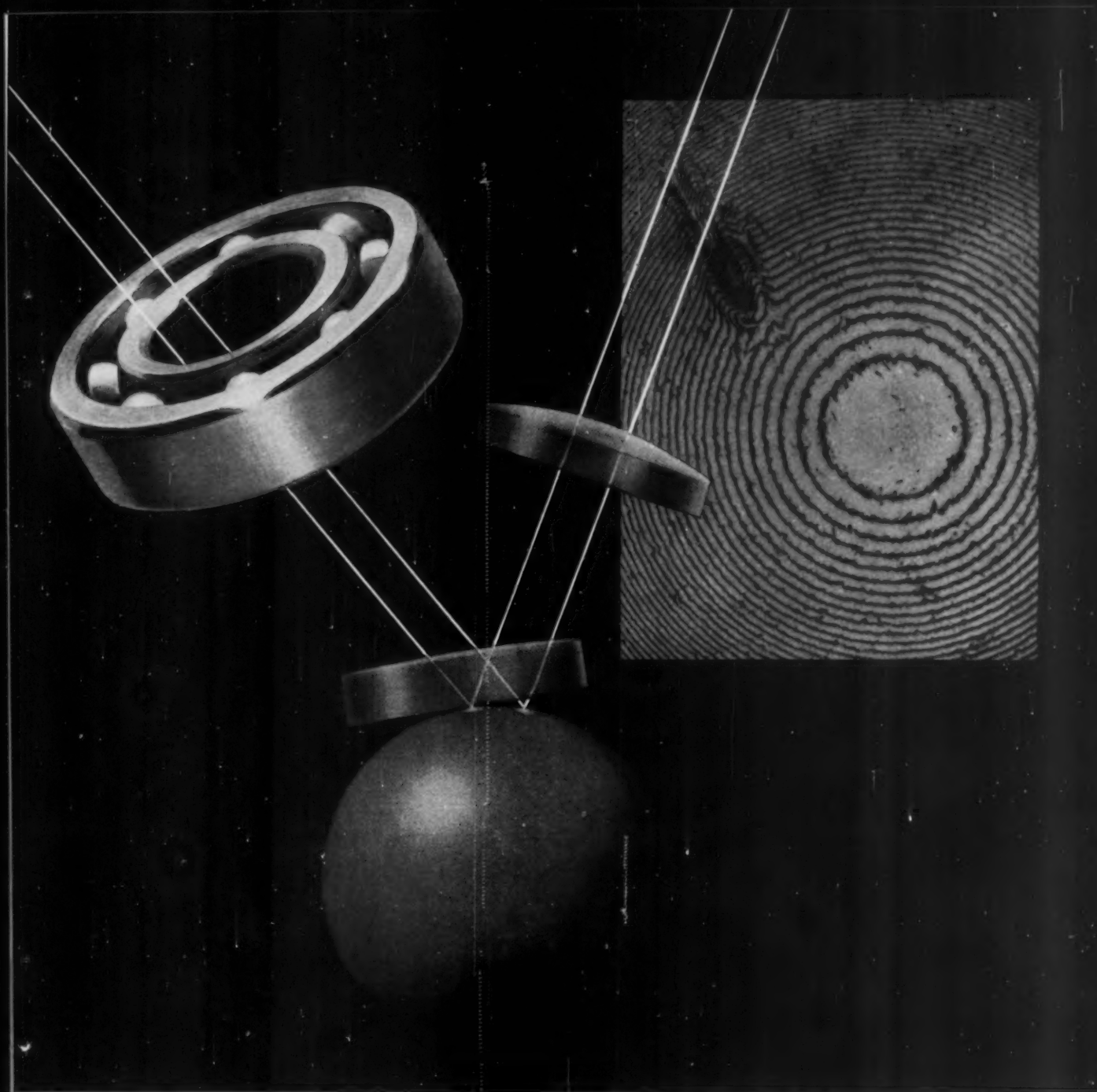

SPLIT LIGHT BEAMS MEASURE IN MILLIONTHS

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Advanced ball and roller bearing technology

The concentric pattern of interference fringes in the picture above is reproduced from an actual photo taken with the aid of an interferometer in the SKF laboratories. The subject under examination is a microscopic flaw in the surface of an accurately lapped steel ball. The principle of utilizing split beams of light to form interference patterns enables accurate measurements to be made in *millionths* of an inch.

SKF is a leader in the development and application of ultra-precise measuring systems. The SKF metrology laboratory plays an important part in a continuing program of research to produce bearings of improved accuracy and finish, and consequently, quieter, smoother running characteristics.

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DEVELOPMENTS TO WATCH...

New materials for electrical and electronic equipment

Three new plastics are among several new materials being readied for commercial use in electrical and electronic parts. Other newcomers are a triple-purpose, heat-resistant material that can serve as semiconductor, luminescent pigment or refractory; and an improved conductive sheeting.

The new plastics include an epoxy rubber for wire-and cable-splicing and damping of cast parts; extruded thermosetting epoxy resins in lengths to 72 in; and a new delayed-action urethane foam.

The rubber is a low-viscosity material that cures to hardness readings in the Durometer-A range, and is said to show excellent adhesion to metals.

The extruded thermosetting material is an epoxy similar to those previously available, but the lengths that can be supplied are much greater—promising considerable savings in component-fabrication costs.

The foam, too, offers fabrication advantages. A pot life of 20 min.—before foaming starts—means more time to do a better job, and greater flexibility in application. It's a good electrical and thermal insulator, and can be produced in densities ranging from 2 to 20 lb/cu ft.

All three were developed by Rad Electronic Plastics, 1466 Herkimer St., Brooklyn 33, NY, and will be marketed by the company.

The triple-purpose new material is aluminum nitride.

In polycrystalline form, says G. A. Wolff of Harshaw Chemical's solid-state research group, high-purity samples show blue luminescence, while doping with manganese and samarium can produce green and red luminescence, phosphorescence, and electroluminescence.

Because aluminum nitride also shows an energy gap of 5 to 6 electron-volts, and resists oxidation in air temperatures to 1800 F, it may also find application as a high-temperature, high-power rectifier.

Finally, because it can retain its strength at temperatures close to 4000 F when protected from oxygen, it may prove useful for refractory crucibles and other refractory equipment.

Sintered samples weighing as much as ¼ lb have been prepared, and it is believed that even larger high-purity samples can be made.

The conductive sheeting, a reinforced vinyl plastic, is claimed to have a lower resistivity and far better shelf life than conductive rubber. It uses nylon or cotton for reinforcement, and the fabric can be coated with vinyl on one or both sides. Unsupported film can also be produced. However, while the reinforced sheeting is expected to be competitive with conductive rubber in cost, thin unsupported films would probably be more expensive.

Among the applications foreseen for the new sheeting by its developer, M J Fassler & Co, Brooklyn, NY are electrical and surgical appliances, and battery components. For surgical use, bactericides can be incorporated.

Simple process makes graphite impermeable

A process that turns ordinary porous commercial graphite into a nearly impermeable solid is claimed by British General Electric. The graphite is merely treated with hydrocarbon vapor at high temperature (generally in the 1500 to 2500-F range) to produce a carbonaceous deposit in the graphite pores, and then heated again to drive out any volatile material that may remain.

Almost any common hydrocarbon can be used—benzene, acetylene, propane.

Heat can be provided by the graphite itself—taking advantage of the conductivity of graphite and passing the heating current right through it. Induction or furnace heating may also be used.

With the system, British GE says, permeability to gases and liquids can be reduced by a factor as high as 1000—after treatment, a given piece of graphite will pass only 1/1000 as much gas or liquid in a specified period under specified conditions as it would have done before.

These bearing materials head for high temperatures

Two metal-ceramic compositions that can run against themselves, unlubricated, with little tendency toward seizure at temperatures to 2000 F, in air or vacuum, are reported by Southwest Research Institute. One is a chromium-alumina-molybdenum-titania composition; the other a tungsten-chromium-alumina. In air at room temperature, kinetic coefficients of friction are in the 0.6-range; at 1500 to 2000 F, 0.3. In vacuum (10^{-5} mm Hg), coefficients are 0.4 to 0.6 at room and elevated temperature.

Also promising: a columbium-base alloy containing tungsten, molybdenum and zirconium. It, too, shows a coefficient of 0.4 to 0.6 in the 1450 to 1750-F range. Wear is somewhat greater than for the cermets, but the metal has much better impact resistance; and, says SRI "its high-temperature strength makes it attractive for journals —running, perhaps, on cermet bearings."

SRI has developed a special friction- and wear-tester for the studies, is testing several unusual lubricants as well.

More data on sliding friction

Friction decreases with increasing temperature in steel-aluminum and steel-tungsten carbide roller systems lubricated by petroleum oils, the Mechanical Engineering Div of Canada's National Research Lab reports.

This is contrary to other findings that show an increase in friction over the 40 to 350-F range. The explanation:

Says F. W. Smith of NRC, there seems to be a shearing effect within the lubricant itself which reduces coefficient of friction. However, he notes, quantitative agreement between results with steel rollers operating against aluminum and tungsten carbide is not good, and additional work is indicated. A study of the mechanical function of the chemical products that result from reaction of the lubricant with the metal surface is now underway.

Radiation aids coating of plastics

Two new systems for coating plastics with surface finishes of dissimilar resins take advantage of high-level irradiation to produce and bond the desired surfacing composition.

In one process, the surface film is simultaneously polymerized and grafted to the base material by irradiation of the surfacing material as it flows, in gaseous form, across the base. With the technique, such base materials as polyvinyl alcohol and cellulose acetate can be coated with vinyl acetate, methyl methacrylate, or any one of several other organics.

In this system, developed in France, a softening agent is used (benzene, alcohol or another organic solvent), and the coating must initially be in gaseous form. Irradiation takes place while the two materials are in contact.

In the other system, a US process, the base material is first irradiated in an oxygen-free atmosphere, then the coating material is introduced in gaseous or liquid form, while the effects of the irradiation persist. Strong, coherent bonds have been produced this way, without affecting the bulk physical properties of the base material.

Both processes are described in British patents, the first to Societe des Usines Chimiques Rhone-Poulenc (BP 850,446); the second to E. I. du Pont (BP 839,483).

How fast the transistor switch?

Which is the fastest transistor? Is it the epitaxial, the MADT (microalloy diffused-base), the PADT (planar alloy diffused) or the ECDC (electrochemical diffused collector)?

Makers of all 4 types are claiming speed records. There's no attempt to confuse. It's simply that different tests are used for speed, and the various types offer a range of compromises between speed and saturation voltage.

Chances are, the industry itself will soon undertake a major standardization and specification program.

Right now, best advice to users seems to be to specify performance rather than type and to test transistors in the specific application under consideration, without placing too much reliance on the charts and tables now in the literature. —ARG

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FROM WASHINGTON . . .

Navy to develop subs powered by fuel cells

The Navy will convert a conventionally powered submarine to operate from fuel cells within the next two years. This year, it will start building a land-based prototype. **Long range, the Navy may build an entire fleet of small attack submarines powered by fuel cells.**

Navy says it can obtain an 80% efficiency ratio now with cells fueled by oxygen and sodium or hydrogen. Conventional and nuclear-powered submarines only obtain about a 40% efficiency ratio.

Though it's admittedly in the research stage, some Navy engineers see fuel-cell development as rivaling the harnessing of nuclear power. And they envision more uses outside of the submarine field than within it—such things, for example, as power for automobiles may eventually prove feasible.

Fuel cell-powered subs would augment, but not replace, nuclear-powered subs. Navy doesn't plan on converting more than one conventional submarine. Advantages of the new power unit shape up like this:

It increases the underwater endurance of conventional subs to several weeks instead of 2 to 3 days; cost of fuel cell-powered submarines is estimated at only ½ to ⅓ that of nuclear-powered submarines; because they are quieter to operate than the nuclear subs, they are less vulnerable to enemy detection; they can be built smaller.

For a long time, Navy has wanted to build a small attack submarine about ⅓ the size of its standard nuclear sub. Size and cost of a nuclear powerplant, however, has prevented this. Fuel cells may be the answer, one Navy source says.

It will likely be three to four years, however, before final decisions are made. And, Navy emphasizes that its program is still in R & D stage.

NASA accelerates Project Apollo for 1965 orbit

The NASA manned-space laboratory, Project Apollo, has been given a one-year speed-up. Now, the space agency says it will put the 3- to 4-man vehicle into an Earth orbit by 1965.

Originally, the first experiments for the vehicle were slated for circumnavigational flights around the moon. Now, however, NASA wants to obtain more information on effects of space radiation and prolonged exposure to weightlessness before lunar flights are attempted.

Three 6-month feasibility studies being prepared by the Martin Co, General Electric and Convair will be submitted to NASA next month. Actual fabrication of the Apollo vehicle is slated to start in 1963. It will be boosted into orbit by the big 1.5-million-lb thrust Saturn engine now under development.

Some $30 million is budgeted for the Apollo program in fiscal 1962. No further increase in money is expected this year.

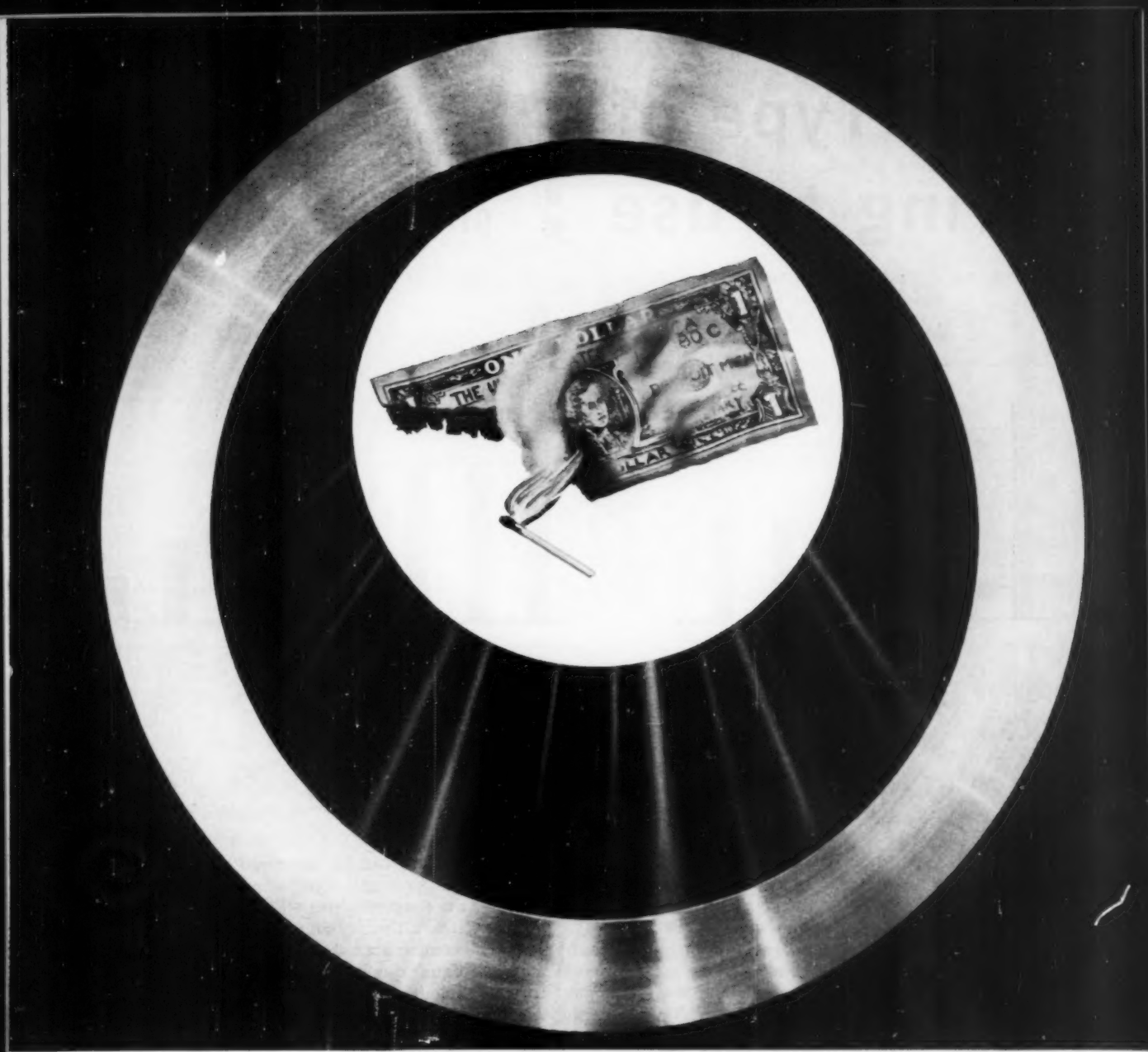
Superjet transport structure to use stainless and titanium alloys

Stainless steel and titanium alloys will likely be the structural materials for the Mach 3 civilian transport aircraft to be developed by the government. That is what NASA engineers are predicting. Heat is the reason for shifting from the conventional aluminum alloy construction.

Skin temperatures for the big aircraft will reach 550 F, the space agency says. Aluminum alloys lose too much of their strength at these temperatures, so a high melting-point metal is needed.

Materials research on the aircraft will be conducted by NASA in a joint development program on the aircraft with the Federal Aviation Agency.

CIRCLE 13 ON READER SERVICE CARD→



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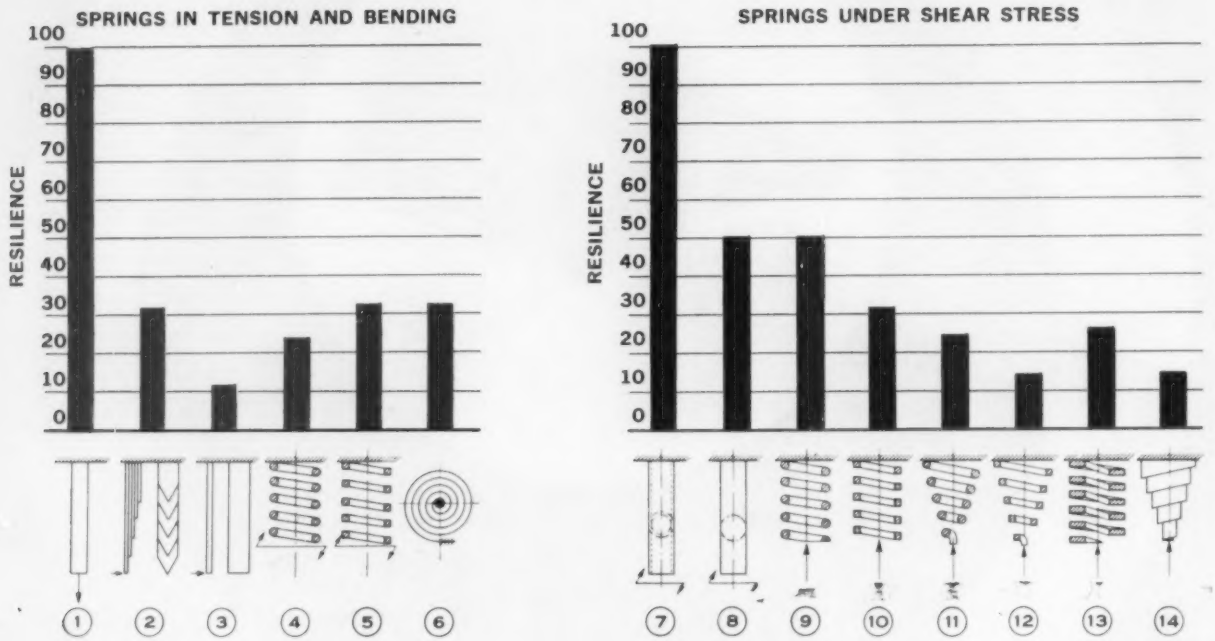
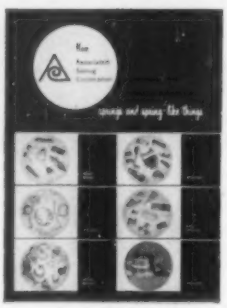
What Type of Spring to use ? Here's a quick comparison of relative efficiencies



1. Simple flat spring
2. Leaf spring
3. Rectangular flat spring
4. Round wire compression spring
5. Square wire compression spring
6. Flat wire spiral spring
7. Thin wall tube
8. Solid rod
9. Round wire spring
10. Square wire conical spring
11. Round wire conical spring
12. Square wire conical spring
13. Rectangular wire spring
14. Volute spring

Relative efficiency of various types of springs can be compared on the basis of energy-absorbing capacity per cubic inch or per pound of metal in the active portion of the spring. For theoretical purposes the simplest forms—wire in tension (1) and thin-wall tube in torsion (7)—represent the ultimate, since all their fibres are stressed alike. The comparisons shown above assume springs are of metal of equal quality, able to withstand the same fibre stress. Obviously, other considerations may affect spring selection such as space available, material desired, atmospheric conditions, manufacturing cost, etc. So efficiency is often tempered by expediency.



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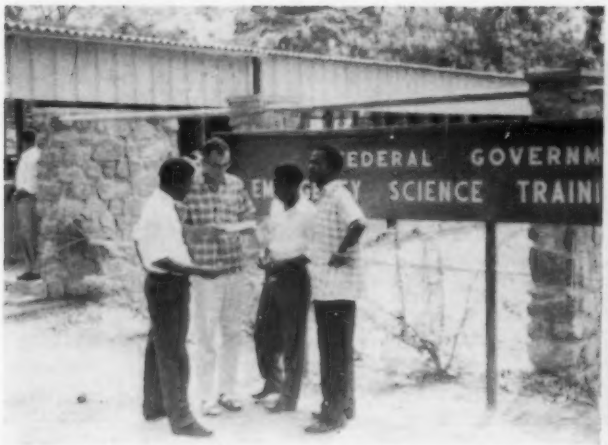
THE ENGINEERING WEEK



STUDENTS ON CAMPUS at Nigeria's Emergency Training School. Instructor at left is Fred C. Hedglin, a US botanist.

New African Nation Self-trains Technicians It Badly Needs

To wipe out disease, malnutrition, and poverty, the Africans desperately want engineers and scientists. But independence has only aggravated the shortage of trained technical personnel. Now comes Nigeria's solution—an "Emergency School." In just three years the program has proved its worth, is ready to expand.

LAGOS, NIGERIA—In Jan 1958, when this country was nearing independence, her new leaders realized something would have to be done at once to replace the many British technicians who were almost certain to return home following the change in governments. This exodus was certain to leave an even more acute shortage of skilled workers than already existed. To correct the situation, the government decided to establish a Federal Emergency Science School.

As its name suggests, the school was originally an improvisation. It has worked so well, however, that it has been enlarged, been made into a permanent institution, and is the model for a number of other technical training schools in the planning stage.

When the government began its crash program in 1958, it took a group of nondescript army barracks on the edge of Lagos and converted them into labs and classrooms. Then it checked its lists of junior clerks for those who had done well in their high school science courses. Two hundred were drafted for the Emergency School's first class. Although drafted, most were happy to leave their desks and filing cabinets. As government servants they made about $40 a month. As professional men their earnings will be at least 10 times that amount.

The curriculum of the Emergency School includes physics, pure mathematics, applied mathematics, chemistry, biology, botany, zoology, engineering drawing and scientific German. Each student takes three subjects (German is not considered a full-time subject). The level of work is equivalent to that of an American junior college.

STUDY TIME LENGTHENED

The 1958 class completed its work in one year, but in order to do so the former clerks were forced to take six lectures plus lab work every day. It was felt that this regimen was too demanding so the course was lengthened to two years. Now a student attends three lectures a day. First-year students spend 7½ hours a week in the labs and second-year students 15 hours.

At the end of two years at the Emergency School, students take the rigorous London General Certificate Examination. Those passing examinations in all three subjects—usually about 40%—are given university scholarships by the Nigerian government. Those who pass only two subjects are still eligible for admission to a British university, and the ones who can scrape together enough money on their own usually continue their studies.

A satisfactory answer has not been found to the question of what to do with the students who don't go on for university work. There is an acute shortage of competent draftsmen, locksmiths, auto mechanics, electricians; so rather than send the former clerks back to their offices, thereby wasting their training, the government may give them further technical training to equip them to fill these other critical areas.

Because travel costs are so prohibitively high, only a few Nigerian students wind up in American and Canadian schools (four Emergency School graduates are now enrolled at MIT). For the amount of money it takes to keep one student in the United States, two can be kept in England, and six in a Nigerian university.

Although initially most of the students come from government offices,

now more come straight from high school. Emergency School now has an enrollment of 650—a third of its students come for night classes after working at jobs all day. Thirty students are girls. The secondary education of girls is still neglected in Nigeria, as in all of Africa, and they are admitted on slightly relaxed standards. To help them pass the same exams at the end of two years, they are given extra coaching by the faculty.

When young people in Africa reach a wage-earning age they are expected to contribute to their family's upkeep. So that full-time attendance at the Emergency School will not be a hardship, the government pays the day students about $40 a month, or the same amount they would receive as clerks.

They are mature, hard-working students who attack their work with discipline.

"They are almost overanxious to learn," says Fred C. Hedglin, a botanist from Chico, California. "Recently I came by the school at 3 am and found some of them sitting under a dim light studying for exams. They practically wreck themselves trying to do too much."

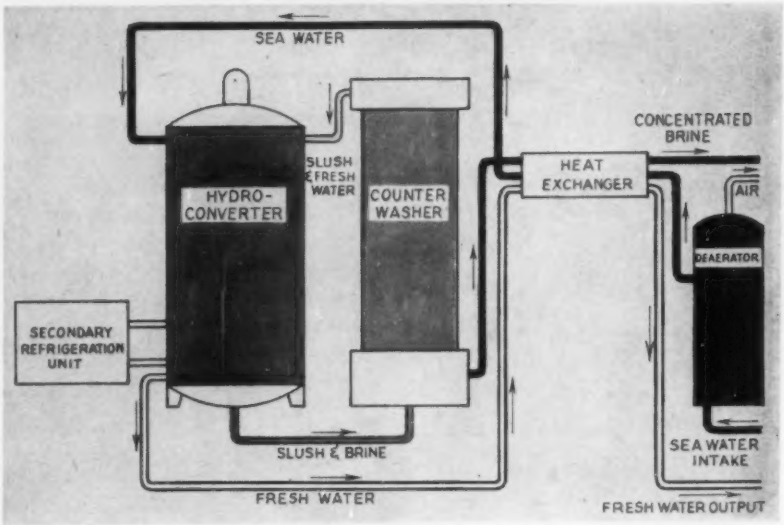
FACE BUDGET PROBLEMS

Hedglin is one of three Americans brought to the Emergency School on an 18-month contract by the African-American Institute. Of the other three full-time instructors, one is English and two Nigerian. There are 18 part-time staff members. Students outnumber teachers by about 40 to 1, partly explaining why the school can operate on its comparatively low budget of $280,000 a year. Despite budgetary problems, the Nigerian government has made the school's laboratories among the best equipped in West Africa (currently three more labs are being prepared for use in the near future).

Now that the plan has proved its worth, the Federal Ministry of Education intends to open similar schools throughout the country. The need is pressing. Although Nigeria has nearly 40 million people, the Emergency School has more than half of all the students in the entire country who are studying science on an advanced level.

—Paul Conklin, Lagos News Bureau

Production to Start on Sea-water Converters



Encouraged by tests on a full-scale sea-water conversion unit, Fairbanks Whitney Corp is tooling for mass production of the converters at its Beloit, Wis, plant, with line production scheduled to start this year. The mass-produced unit evolved from the vacuum-freezing process developed by Israeli scientist Alexander Zarchin. Data accumulated so far have convinced company engineers—and engineers from Israel who have taken part in the joint effort—that this unit will operate below the cost of the most economical commercial system now in use ($1.75 per 1000 gal). First desalting unit, together with additional units to be produced in coming months, will be installed in Israel at Elath—near the Red Sea—and produce about 250,000 gal. of converted sea water daily.

Electric Auto Sparks a Growing Interest by Utilities

KNOXVILLE, TENN—TVA has joined industrial companies operating the Henny Kilowatt, an experimental electric auto made by the Eureka-Williams Corp, Bloomington, Ill. This brings to 48 the number of cars sold to utilities and other firms, including GE and Westinghouse.

All have been purchased on an experimental basis to get data on performance and operating costs as a guide to further development. Many of the utilities would like to see the car become competitive as a second family car for local driving, because its batteries could be recharged at night, helping boost electric consumption during off-hours.

Latest models of the car have an automatic gear shift, which gives the operator a wider choice between speed and range, according to H. J. Allemang, president of Eureka-Williams. The gear shift is operated by a 6-step electrical circuit; it varies battery power from 18 volts, when the operator first presses the accelerator, to 72 volts at top speed. Originally, transmission was set in second gear, allowing 30-mi speed for a 50-mi charge. Now the driver can run in high gear at 40-mph speed for a 40-mi charge.

Power is provided by twelve 6-v batteries, which are recharged through a standard 110-v outlet. The batteries are located in the trunk and motor compartment of a Renault-Dauphine body. Newer models are equipped with a built-in internal battery charger. In early versions, purchaser had to buy his own.

Though experience with the cars is still too limited for reliable data on operating costs, Atlantic City Electric Co, an ardent advocate of the electric vehicle, estimates it could be operated daily for $75 a year. This assumes one full charge a day, at the utility's prevailing electric rates. The company now has four such cars—being driven by meter readers, home economists and appliance personnel who have small territories to cover. TVA estimates that fuel costs will average about ¼¢ per mile with its low elec-

tric rates—about $40 a year for a 40-mi daily charge.

But not all users view Henny Kilowatt's potentials with undiluted optimism. For city driving, the vehicle is said to be too slow to keep with normal traffic flow. And the bulky cargo of batteries sharply curtails space. Also, the vehicle is still expensive, retailing at $3650.

PE Cited for Safety Work

CHICAGO — PRODUCT ENGINEERING magazine is one of 57 specialized magazines in the US to be named a winner of the National Safety Council's Public Interest Awards for 1960. The award is made "in recognition of leadership, initiative and originality by the mass media in the promotion of accident prevention."

PE's contribution was made in the form of numerous editorials, news stories and special features, such as "A Manual of Reliability," *May 16, '60, p 63*; "From Failures Come Better-engineered Missiles," *May 16, '60, p 15*; "The Mark of Cain," *Nov 7 '60, p 53*. ■

Insurance Company Unveils Safer Version of Safety Car

NEW YORK—Some 24 design changes have been incorporated into the Survival Car II, shown here recently. This second-generation vehicle designs into a conventional production-line auto the key safety features found on the original Survival Car developed jointly in 1957 by Liberty Mutual Life and Cornell Aeronautical Labs.

Most unusual innovation are two high-backed bucket seats to replace the standard 3-place front seat. Equipped with seat belts and shoulder harnesses, they will hold a passenger in place during head-on collisions at 30 mph; will also withstand 30-g impacts and support 5000-lb loads if the car is struck from sides or rear.

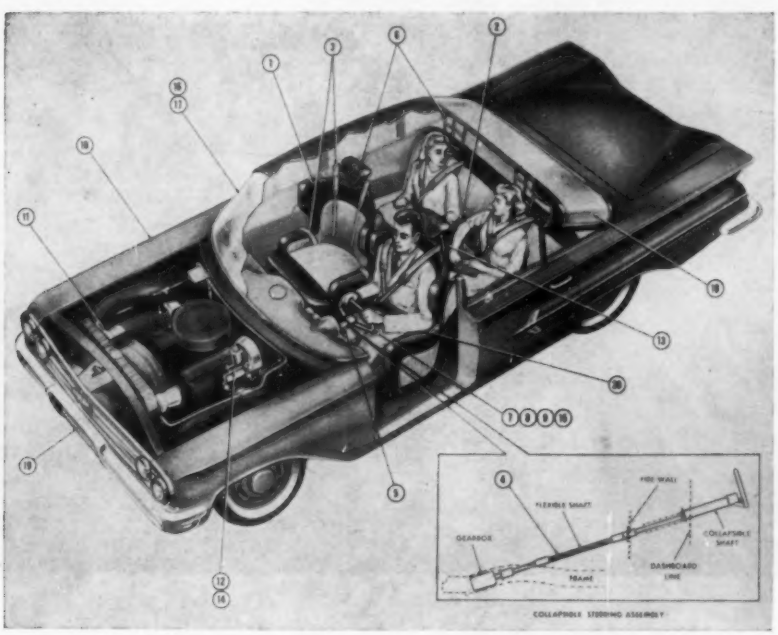
The seats resemble in principle those on the earlier model, but are adapted to the smaller interior dimensions of today's Chevrolet, Ford or Plymouth. The original Survival Car concept called for surrounding the passengers with an envelope of space, sufficiently large to keep them from striking each other or parts of the car, when restrained by a seat belt alone. This would have required about 45-in. clearance ahead of the passenger. Harnesses are now included to hold the fragile human cargo in place. Each chair is secured to the car floor by a steel casting. Slots milled into angle bars that anchor the seat allow the assembly to move back or forward a maximum of 4 in. This softens the force of a sudden impact.

In addition, the car's steering mechanism has a 21-in. flexible insert between gearbox and fire-wall which will buckle to prevent the driver's being impaled on the steering shaft in a crash, and a steering tube that telescopes away to prevent face and chest injuries. The steering wheel is rectangular and somewhat smaller than the conventional circular wheel. This alteration has the dual advantage of preventing injury to the driver's kneecap when the wheel telescopes, and increasing visibility under normal driving conditions.

The latest Survival Car has unit body construction which has high energy absorption. It will collapse on severe impact, leaving the car in ruin, but the passengers are protected from body damage, according to the car's designers.

External lines have been smoothed to minimize hazard to pedestrians struck by the moving vehicle.

The motor compartment has a carbon dioxide-releasing device to quench fire. It is triggered automatically by an abnormally rapid temperature increase or can be activated manually should the automatic system fail.



SAFETY FEATURES designed into Liberty Mutual's Survival Car II include: (1) capsule chairs, (2) protection of rear-seat passengers against 5000-lb blow, (3) seat belts and shoulder harnesses, (4) flexible steering shaft, (5) collapsible steering tube, (6) whip-lash protection, (7) rectangular steering wheel, (8) reduced-dia steering wheel, (9) faster response to steering-wheel turns, (10) unit body construction, (11) fire-control system, (12) safety brake device, (13) rollover bars for head protection, (14) power brakes, (15) power steering, (16) laminated safety windshield, (17) Saflex interlayer windshield to eliminate 95% of ultraviolet rays, (18) tinted windows to reduce outside heat entering car, (19) reflective license plates, (20) arm supports to reduce passenger fatigue.

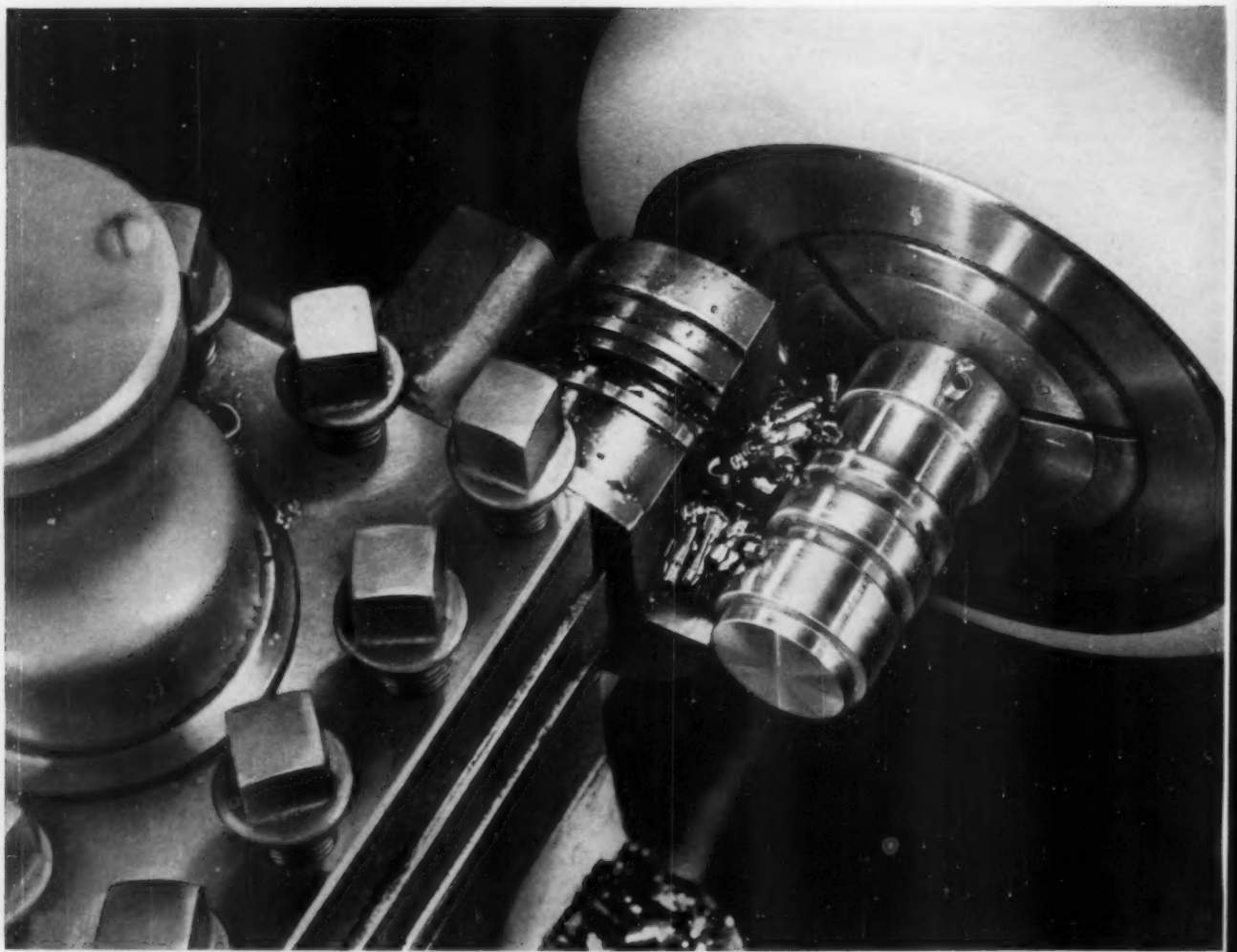
Congress Hears Debate on Safety

In Washington, auto safety has become a focus of legislative interest. Three bills are now before the House Health and Safety Subcommittee: One would curb sale of unsafe or substandard brake fluids; another would establish an advisory committee on procurement of federal motor vehicles "incorporating a selected list of available proven safety equipment as the Secretary of Commerce deems appropriate"; the third would impose federal standards on safety features of motor vehicles sold, shipped or used in interstate commerce.

Several groups have testified on

continued on page 20

CONTROLLED HARDNESS—Your key to costs with Armco Stainless Types



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ARMCO **Armco Division**

continued from page 17

the proposed legislation, including the Auto Manufacturers Association, the American Trucking Association, the National Safety Council, Chrysler Corp and the Insurance Institute for Highway Safety.

In its presentation, the Automobile Manufacturers Association supported the bills to prevent sale of substandard brake fluids, and govern procurement of safe government vehicles (although the association suggested that establishment of federal standards be left to a committee rather than the Secretary of Commerce). On the third bill the AMA vigorously opposed any legislation imposing federal safety standards on vehicles sold interstate.

Basically, AMA objected that safety is an integral part of auto design; hence standardization of isolated features would be impractical. This criticism was applied to several specific safety components called for—in safety padding, steering and vehicle controls, and such shock absorbers as bumpers and fenders.

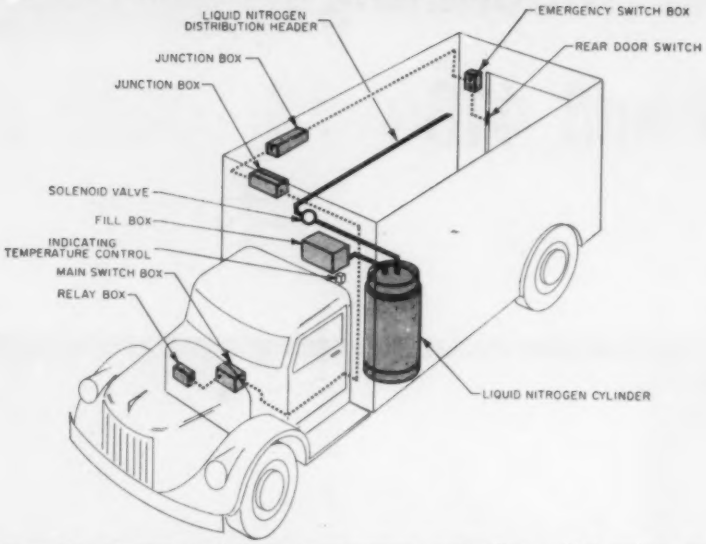
The AMA further contended that adequate lighting standards have already been promulgated by industry and government and are now being enforced. Likewise, standards for brake performance are enforced by the ICC and individual components are covered by SAE standards.

At present, the AMA argued, the most serious mechanical safety problems arise from inadequate maintenance by owners. It therefore wants an educational campaign and state legislation calling for periodic inspections.

Likewise, AMA opposed horsepower limitations or installation of governors limiting auto speed to 80 mph—again contending that the problem is one of law enforcement and education.

Speaking as an individual with traffic-safety experience, Russell I. Brown, now president of the Institute for Public Safety, also opposed the mandatory governors. He contended that they would limit the ordinary driver's decision-making ability on the road, and could be justified for restraining fewer than 1% of drivers. But most of these, he warned, intend to break the law and would tamper with the governor. State laws, he said, are better speed controls. ■

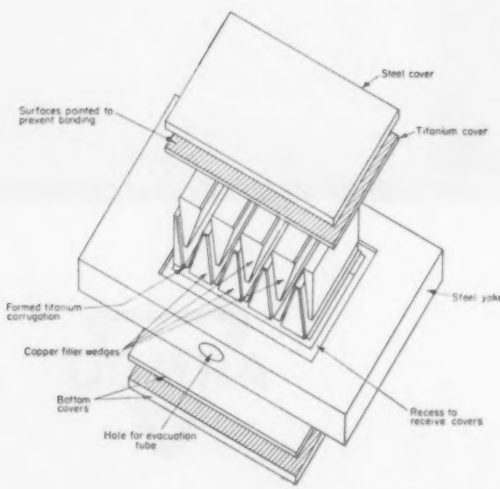
Sprayed Nitrogen Reduces Refrigeration Costs



Four parts—storage container, temperature controller, relief valve, spray header—form the basic system of Linde Co's Polarstream refrigeration unit for trucks. Truck cargo area is maintained at any desired temperature by spraying liquid nitrogen from a header in the roof. Temperature controller actuates a solenoid switch when temperature rises above set amount. At a delivery point, the system is inactivated by a switch in the cab. If switch is not tripped, opening the cargo doors will stop the system. To reactivate, the reset button in cab must be pushed. The safety system includes an inside-the-van emergency button that sounds horn as well as turning system off if driver is accidentally locked in and system started. Linde claims entire installation costs less per btu of refrigeration than any other unit; a filled 20-in. dia container weighs 475 lb.

New Process Cuts Sandwich Panel Cost

Through a new process called roll-welding, Battelle Memorial Institute and Douglas Aircraft have lowered the cost of corrugated-core sandwich panels. The method first weaves an accordion-pleated sheet (in this case, titanium) over and under V-shape inserts of chemically soluble, deformation-resistant metal such as copper. A metal yoke is then wrapped around the core and titanium cover sheets for the sandwich are laid over the corrugated titanium. Next, this entire assembly is clamped in place by two steel cover sheets welded to the yoke. The assembly is hot-rolled in a direction parallel to the corrugations; this welds the core to both its covers and reduces thickness of the panel up to 60%. After rolling, the retaining yoke is sawed or sheared off and the metal covers, welded to it, are pealed away. With support wedges still in place, the sandwich panel can be formed into a variety of shapes, including hemispheres, without buckling. The panel can be worked with standard tooling as though it were a solid metal plate. When the desired shape is achieved, the V-shape inserts are leached out with a chemical reagent such as nitric acid. Panels as large as 36 by 72 in. have been produced in aluminum, steel, molybdenum and Iconel as well as titanium.



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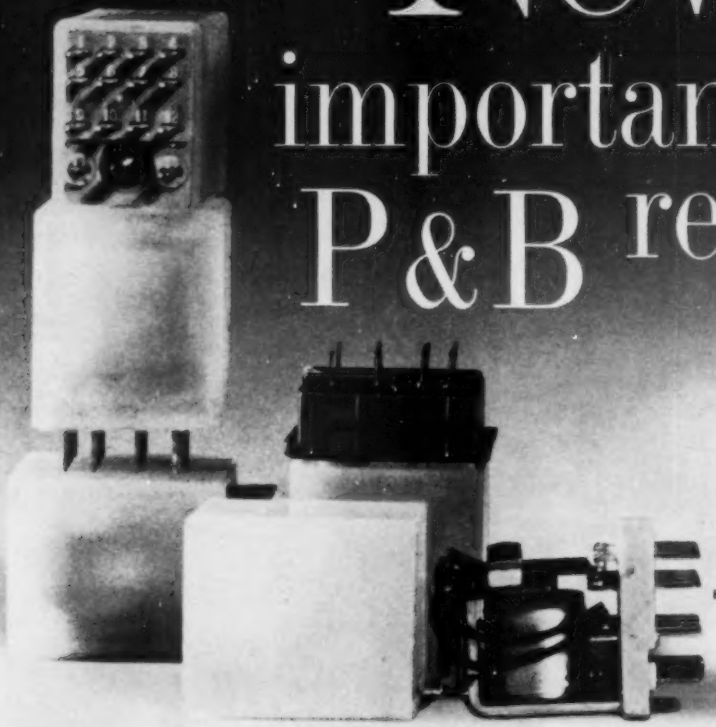
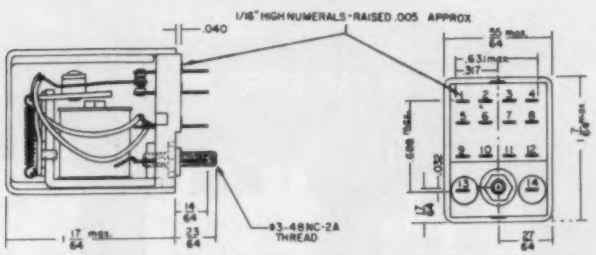


KHP SERIES SHOWN ACTUAL SIZE

having rare longevity

This small, 4-pole relay has the happy faculty of maintaining its original operating tolerances over an exceptionally long life. Example: tests (by customers!) show this relay has variations in electrical characteristics of less than 5% after more than 100 million operations.

But that's far from all. This is a *small* relay . . . about a one inch cube. This relay is easy to install using the conveniently spaced solder lugs or a socket. Thus you save time and production costs. This relay is versatile . . . its 4PDT contacts will switch loads from dry circuit up to 3 amperes. This relay—well, why not order samples and see for yourself! Order today from your P&B representative or call us at Fulton 5-5251, in Princeton, Indiana.



KHP SERIES SPECIFICATIONS

CONTACTS:

Arrangement: 4 Form C, 2 Form Z.

Material: 1/32" dia. Silver standard. Silver cadmium oxide and gold alloy available.

Rating: 3 amps @ 30 volts DC or 115 volts AC resistive for 100,000 operations.

COILS:

Resistance: 11,000 ohms max.

Temperature: Operating Ambient: —45°C. to +70°C.

Power: 0.5 watts min operate @ 25°C. 0.9 watts nom. @ 25°C. 2.0 watts max. @ 25°C.

TIMING VALUES:

Nominal Voltage @ 25°C.	Max. Values
Pull-in time	15 ms
Drop-out time	5 ms

INSULATION RESISTANCE: 1500 megohms min.

DIELECTRIC STRENGTH:
500 Volts RMS 60 cycles between contacts.
1000 Volts RMS 60 cycles between other elements.

MECH. LIFE: In excess of 100 million cycles.

SOCKET: Solder lug or printed circuit terminals. Available as accessory.

DUST COVER: Standard.

TERMINALS: Solder lug and taper tab.

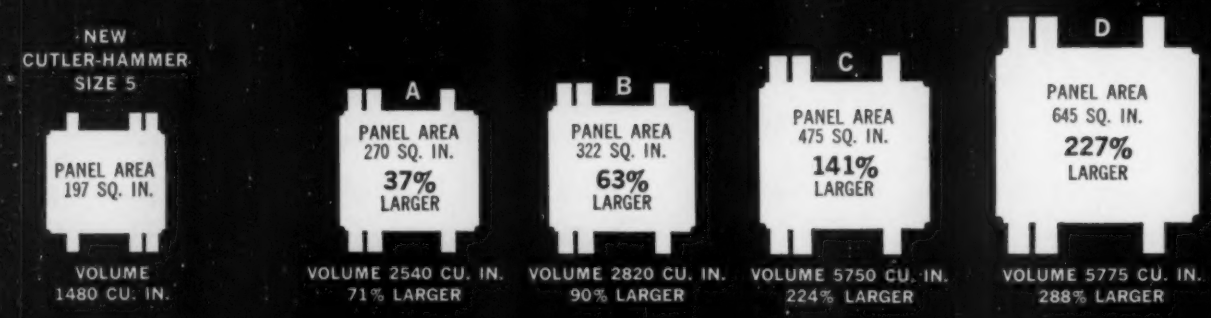
KHP SERIES RELAY NOW AVAILABLE AT YOUR LOCAL ELECTRONIC PARTS DISTRIBUTOR

POTTER & BRUMFIELD

DIVISION OF AMERICAN MACHINE & FOUNDRY COMPANY • PRINCETON, INDIANA

IN CANADA: POTTER & BRUMFIELD, DIVISION OF AMF CANADA LIMITED, GUELPH, ONTARIO

THE NEW CUTLER-HAMMER SIZE 5 STARTER IS FAR MORE COMPACT THAN OTHERS



Now! A complete line of easy-to-install Cutler-Hammer Starters including a new compact Size 5

7 sizes for use as components or as complete starters

(Size OO, O, 1, 2, 3, 4 and 5)

Now get all the advantages of Cutler-Hammer's Three Star starter line in seven sizes. You can control motors from fractional hp up to 200 hp, now that the new Size 5 is available.

The new Size 5 starter needs only an eight-inch deep case. Its open dimensions are only 13″ wide, 15 3/16″ high, 7½″ deep . . . and is available as a non-reversing or reversing starter or as a contactor.

Even the wiring's easier. Instead of struggling to force the line and load cables into the lug connectors, the lugs unbolt, and are easily reassembled.

You still get, of course, the famous Three Star advantages that have made Cutler-Hammer Starters so famous: dependable pivoted armature, vertical contacts that don't collect dust, ease of installation, ease of inspection and maintenance, plus many other features.

Be sure to send for Pub. LO-16-J249 to get all the facts on the complete Cutler-Hammer Starter line.

What's New at Cutler-Hammer? There's a new spirit here. You can see it in the new products, the new engineering talent, the increased plant capacities. We're ready for the great growth of the sixties so you can be ready to meet the great demands upon your capacities. We'd like to tell you more. Contact the Cutler-Hammer electrical distributor or the Cutler-Hammer sales office nearest you.

WHAT'S NEW? ASK...

CUTLER-HAMMER

Cutler-Hammer Inc., Milwaukee, Wisconsin • Division: Airborne Instruments Laboratory • Subsidiary: Cutler-Hammer International, C. A. Associates: Canadian Cutler-Hammer, Ltd.; Cutler-Hammer Mexicana, S. A.

TRENDS IN INDUSTRIAL DESIGN

Engineer and Designer look at the INTERNATIONAL AUTO SHOW

ALBRECHT GOERTZ, Goertz Industrial Design Inc, NYC
JOSEPH J KELLEHER, associate editor

■ As we looked down from the New York Coliseum's third-floor balcony exhibit area at the main floor of the show, the overwhelming impression was one of confusion. First, there was the first large-scale invasion of this annual show by the American automotive producers. Then there was the tendency—common to European and American designers alike this year—to copy each other's design cliches. A number of the American cars in the show are essentially still family sedans, decorated with the standard accoutrements of European sports and racing cars. And virtually all the European sedans copy slavishly the worst of Detroit's artifices with chrome and fins.

Painfully evident is the lack of any functional approach to applying the power of a combustion engine to transporting two to six passengers and their paraphernalia over streets and intercity highways. Even those European producers most noted for the attractive distinctiveness of their products in the past have begun to make their cars as much like the rest of the market as possible.

All this has led to a state of oversupply throughout the industry, both here and abroad—particularly in terms of small and medium-size sedans, with virtually everyone of the domestic and foreign producers feeling compelled to present a number of models only superficially different from all the others available.

And the consumer is reacting to this situation, even when he must pay far above the average price for a car that's different. This was reflected by the tremendous sale of such distinctive new cars as the Jaguar XK-E. ■

JAGUAR XK-E (see cover)

GOERTZ: The most exciting car of the show; at least one reason is that the car remains clearly a Jaguar (see racing version, Model D, at right, below). The manufacturer has resisted the trend towards Italian and American design cliches. However, in one way—passenger comfort—this sports version is stil too close to the competition model.

KELLEHER: Undoubtedly the most impressive car at the show, but I'm afraid that this new model's immediate predecessor was a more successful design as a racing car than the XK-E is as a passenger vehicle. Too many of the new car's details—the chrome trim in the otherwise aerodynamic air scoop, the turn indicators, chrome tail pipes and bumperettes—have that tacked-on look. All the emphasis on appearance and performance means user comfort comes in a poor third.

A

B

LANCIA CONVERTIBLE COUPE and FLAVIA SEDAN

GOERTZ: The coupe (A) represents a good relationship of elements, hence a successful design. The Flavia (B) consists of the same elements but in different proportions—not successful. Stocky, but not what one would expect from an Italian designer with such a distinguished record of gracefully designed autos.

KELLEHER: The best examples yet of how—and how not—to handle twin headlights. On the Lancia coupe, a lot more time and thought was given to this problem—but why bother with twin headlights anyway? On the Flavia, the headlights merely strengthen the car's strong resemblance to a Checker cab. General boxy shape (photo, left) is poor, and overhang on trunk looks like a fat girl with a too-tight girdle.

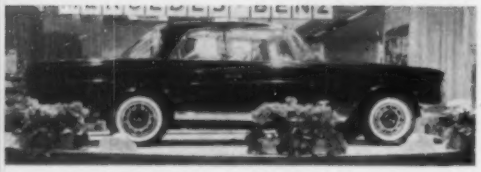
PONTIAC TEMPEST "LE MANS" SPORTS COUPE

GOERTZ AND KELLEHER: Bucket seats, wire wheels, rpm-counter (note mounting on driveshaft tunnel) and a floor shift do not a sports car make—at least not out of a standard Tempest body and suspension.

KELLEHER: Bucket seats are not only attractive and simply styled but are comfortable. Floor shift is located nicely, but in reverse, shift knob comes up between legs. Location of tachometer is dangerous and shows designer did not understand purpose of such an instrument in a car.

DKW S-1000 COUPE

GOERTZ: Very reminiscent of 1957 Thunderbird. What happened to company—and product—identity?
KELLEHER: A good little car because of what designers have not done rather than what they did—they left the chrome off the sides and rear. Weakest points: tubular headlight treatment (note "bug-eyed" look) and phony air scoop on hood. Even so, proportion and scale are good and car has unified look, a rare thing in automotive design.



MERCEDES-BENZ 220SE 4 HARD-TOP COUPE

Both Goertz and Kelleher emphasized this car's heavy, Teutonic look. In appearance, does not give the feeling of a sports car, despite its rpm-counter and floor shift.

BUICK SKYLARK

GOERTZ: Clean, honest styling; by far the best of the three GM compact series (Buick, Oldsmobile, Pontiac). Very neat rear-end details; front-end treatment is weak, though.

KELLEHER: Buick deserves credit for keeping it simple—that is, simple for Detroit. Weakest part of design is attempt at blending fenders into grille, resulting in some tortured sheetmetal convolutions.

THUNDERBIRD (see cover)

GOERTZ: What is a sports car? Certainly not just a low and somewhat more uncomfortable 4-5 passenger body on a Ford chassis. Should not have wheels—instead would make a beautiful boat!

KELLEHER: This is the closest thing to a grand-touring car produced in the United States today, but the use of an automatic transmission; soft, family-sedan type of suspension; and many other basic components of the standard Fords limit the sports-car performance that the low center of gravity and extremely powerful engine are capable of delivering. There has been a complete loss of identity between this Thunderbird and the original 1955-56 model (still one of the most attractive cars Ford has produced). Any further rise in sales volume will probably see even further compromise; I would not be surprised to see the standard Ford convertible disappear and this car take its place.

VOLVO P-1800 SPORTS COUPE

GOERTZ: A Swedish car with Italian design influenced by US styling.

KELLEHER: The chrome squiggly and the egg crate mashed into the air scoop look as though they were designed without the car in mind. I think even Detroit has now realized that this is wrong.

DB COUPE

KELLEHER: This photo is included just to show that even the ugliest car can have something worthwhile. The wheels present a solution to an engineering and an appearance problem. Enveloping body sheetmetal prevents cooling air from reaching the brake inside of the wheel, so DB projected the brake through wheel out into the cooling airstream. This also does away with phony wheel covers.

READER TO EDITOR

Powered Reel Catches Fish

To the Editor:

I noticed you had a paragraph in your Jan 23 "Why Don't They R & D?" column, p 32, a request for a powered fishing reel. It may interest you to know that I have built and have been using my powered spin cast reel for more than a year. It works very smoothly and has a 6-pound pull at the tip of the pole. I have caught a number of fish by using it. My only problem is to get it patented and in production. I would like to offer it to some company. —E. L. BAUER

Overseas Engineering Div
Proctor & Gamble Co

• Any takers?—Ed.

Moral Questions and Engineering

To the Editor:

I am pleased that PRODUCT ENGINEERING has been raising moral questions about some of the work engineers are called upon to do. An editorial on nuclear weapons, (Feb 13, p 35) raises a serious problem that affects those engaged in developing the vehicles to deliver those weapons: "And there is great need for doing something positive to control our environment before the Juggernaut we are creating runs us down."

Some scientists went through soul-searching over the matter of developing nuclear weapons. The answer, for some, was to have nothing to do with nuclear weapons, or any other destructive work. They formed an organization, Society for Social Responsibility in Science, to foster the tradition that a scientist is morally obligated to use his talents for constructive rather than destructive purposes.

Some perspective is needed before accepting too readily the case for vehicles to deliver nuclear weapons. Shall civilization be destroyed over a dispute between two governmental systems which would probably both be quite different in 100 years without war? —WALTER GORMLY

Mt Vernon, Iowa

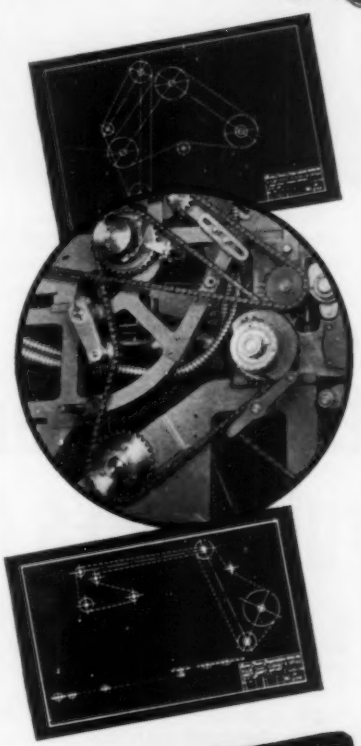
Machine Designer or Noise?

To the Editor:

In your editorial article in the Mar 6 issue, p 37, you reduce the designer, draftsman and mechanic to "noise." I feel obliged to present an opposite theory from the standpoint of the machine designer. Machine design, as taught in colleges, and as understood by this writer, is an exercise in practical transformation of energy to a predictable and useful result, and was surely not intended to be simplified to the extent of catalog selection.

I would say that your ideal brand of "creative" engineer would be well advised to treat machine design with the utmost respect before he deems himself capable of design. From the machine designer's point of view this is not the twilight, but the dawn. Increase the flow from the research scientist through the computer to the true machine designer, and face the

continued on page 30



In engineering service and delivery from the manufacturer

Each dollar invested in Acme Chain buys the highest quality product that experience, material, design, craftsmanship and facilities can produce at competitive prices. But your dollar value doesn't end here. Acme has built its enviable reputation for giving its customers fast excellent engineering and technical service from start to finish.

Whatever the problem, Acme's Engineering Department has always been on hand to supply its customers with a fast practical solution.

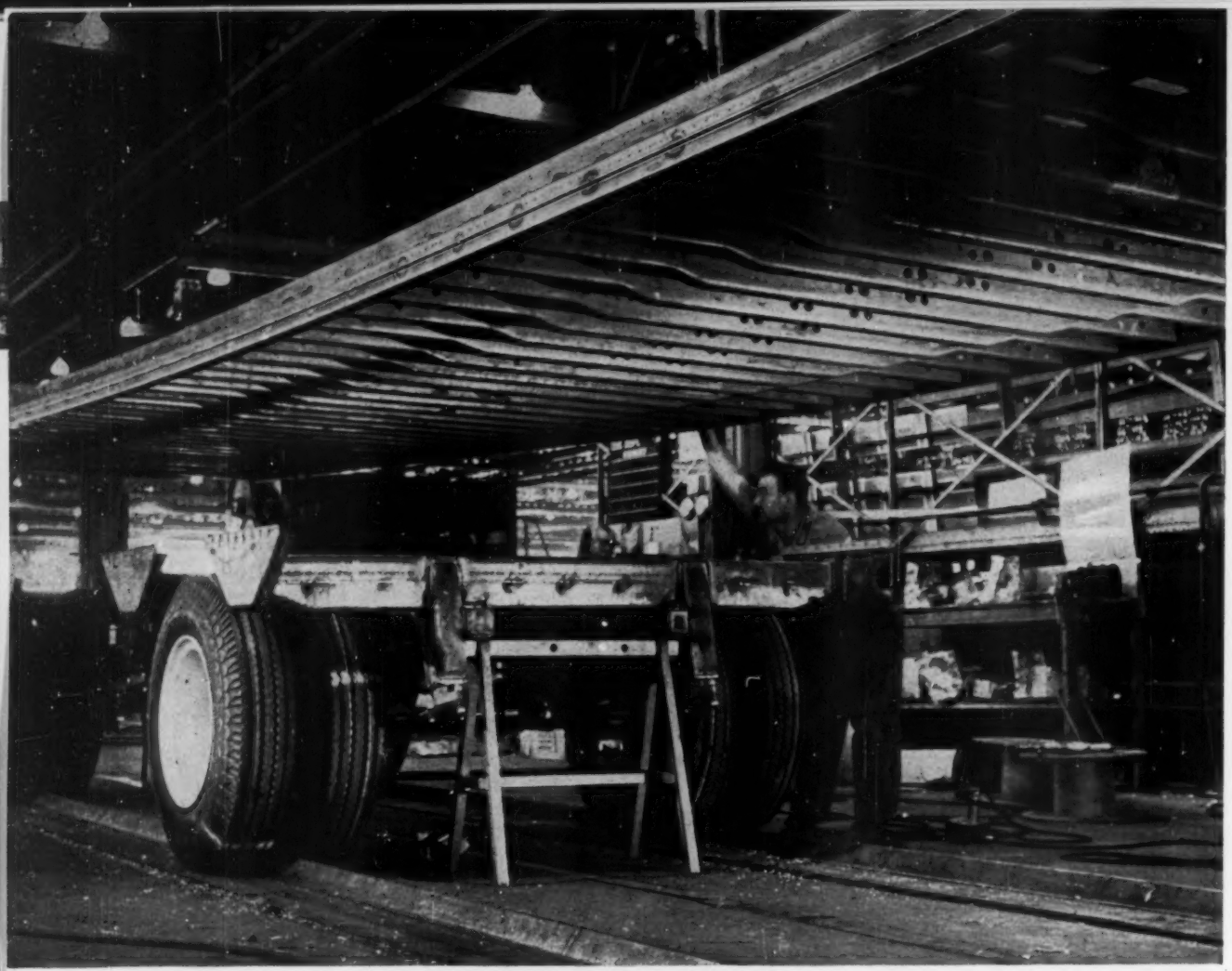
Be sure you get this extra value from every dollar you invest in roller chains. Consult your nearest Acme Distributor or write our Engineering Department for the answer to your power transmission or conveying problems.

Acme Chain Corporation
HOLYOKE MASSACHUSETTS

Write Dept. I-T for new ill. 100 page catalog with engineering section.

RELIABLE CHAIN DRIVES FOR ALL INDUSTRIES

ROLLER CHAINS, SPROCKETS, CONVEYOR CHAINS, FLEXIBLE COUPLINGS, ATTACHMENTS. (Special and Standard)



At Fruehauf Trailers' huge Avon Lake, Ohio, plant, crossmembers made from PITT-TEN high strength structural sheet provide 22 percent more payload.

Here, on the assembly line, a Fruehauf trailer bed made with Pittsburgh Steel Co. PITT-TEN is swung onto the underconstruction assembly.

As Trailer Bed Crossmembers

Fruehauf Gets 22% More Payload With Pittsburgh Steel's New PITT-TEN

Twenty-two percent more payload—that's what Fruehauf is building into the framework of giant trailers assembled with crossmembers made of PITT-TEN, Pittsburgh Steel Company's new high strength structural sheet.

Fruehauf uses PITT-TEN #1 at its Avon Lake, Ohio, plant—the largest trailer manufacturing facility in the world—because it offers a combination of benefits that . . .

- **Cuts deadweight with no loss of strength**
- **Lengthens service life through superior corrosion resistance**

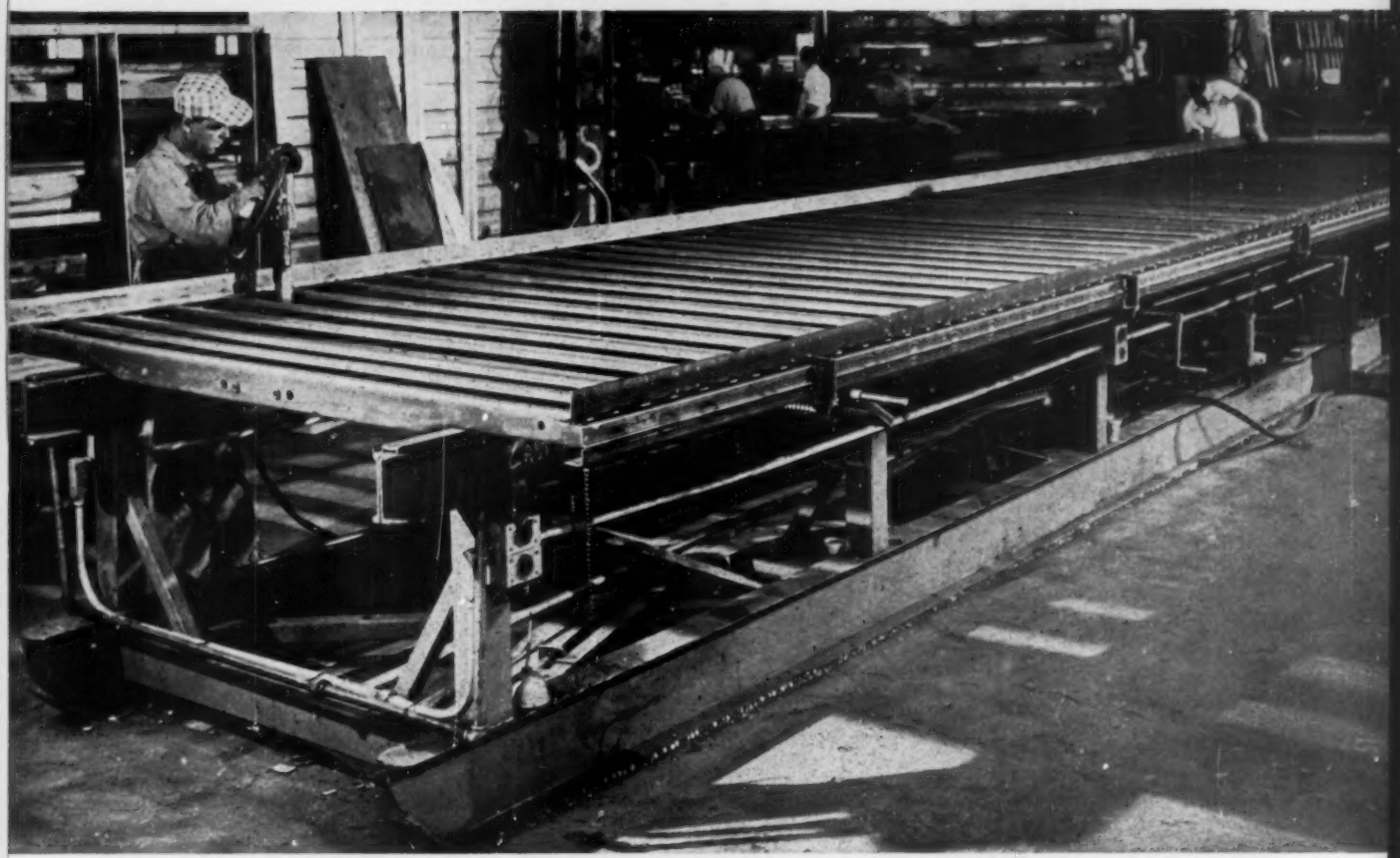
• **Light Yet Strong** — Fruehauf tries to make its trailers as light as possible with no sacrifice in strength. Trailer bed crossmembers made of high strength PITT-TEN are lighter, for equal strength, than mild steel.

The weight saving amounts to more than eight pounds for each piece. That's because three pounds of PITT-TEN do the work of nearly four pounds of ordinary sheet steel. At the same time, it provides all the strength needed for years of hard use.

Corrosion resistance is another problem in trailer operation. Fruehauf trailers are used under all types of conditions that could create maintenance headaches if the proper material were not used.

PITT-TEN #1 has four to six times the resistance of carbon steel to atmospheric corrosion. So, Fruehauf specifies PITT-TEN to reduce maintenance costs.

The trailer part basically is a channel 93⅞ inches long, 2 inches deep and 3 inches wide. Its width is expanded to 4½ inches on one side by an offset that extends most of its length. In addition, a ¾-inch



During assembly of Fruehauf trailer bed, cross-members made from high strength structural PITT-TEN are riveted to the side rail. PITT-TEN #1 reduces maintenance requirements of Fruehauf trailers through superior corrosion resistance. It has four to six times the corrosion resistance of carbon steel to atmospheric corrosion. PITT-TEN also cuts deadweight with no loss in strength.

return flange is applied full length to both edges.

Fruehauf engineers point out that forming this piece with offset and flange in high tensile steel would be a tricky business without consistent quality — and with PITT-TEN Fruehauf has a steel that does the job.

PITTSBURGH STEEL NEW SOURCE – This is one of several applications which mark the entry of Pittsburgh Steel in the high strength steel market, one of the fastest growing in metalworking.

That means this:

Fabricators of high strength steel structurals—or any product where the weight/strength ratio is a factor—now have a new source of supply.

In the eight years Pittsburgh Steel has been producing flat-rolled products, it has become recognized for the unexcelled quality of its steel sheet and strip. Now PITT-TEN is being produced by the same fine steelmaking and steel rolling facilities which have earned that reputation for quality.

PITT-TEN is produced in three grades, each with specific physical properties. Briefly, here they are:

PITT-TEN #1—An all-around high strength structural sheet that offers a combination of benefits. First is greater strength without increased weight; or equal strength with a lighter section. Second is longer product life, less maintenance through greater resistance to corrosion (four to six times that of mild carbon steel.)

PITT-TEN #2—high strength sheet with exceptional formability. This grade is produced to tensile and yield requirements to meet forming problems of specific fabricated parts.

PITT-TEN "X"—produced to guaranteed minimum yield points of 45,000 and 50,000 psi. This grade is especially useful where the controlling factor is a reduction in weight without loss of strength.

If your product's success depends on weight/strength factors, then Pittsburgh Steel's new PITT-TEN can benefit you, too.

Let one of our service metallurgists show you how. They're as familiar with steel fabricating problems as they are with steelmaking problems. Just contact one of the sales offices listed here.

Pittsburgh Steel Company

Grant Building • Pittsburgh 30, Pa.

DISTRICT SALES OFFICES

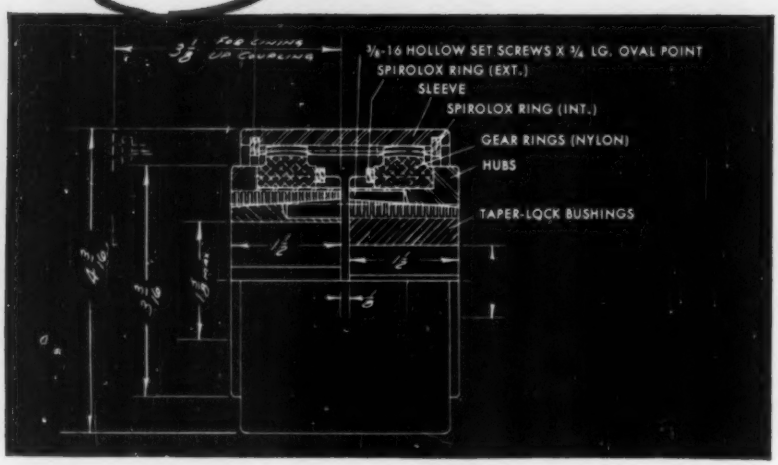
Atlanta	Cleveland	Dayton	Los Angeles	Pittsburgh
Chicago	Dallas	Detroit	New York	Tulsa
		Houston	Philadelphia	Warren, Ohio

Steel

CIRCLE 29 ON READER SERVICE CARD

design facts....on

WALDRON
Series "M"
Couplings



The new Series M couplings—with nylon gears and steel sleeves—need no lubrication. Equipped with Taper-Lock bushings—each coupling size can accommodate a range of shaft sizes. For instance, the 162M, now available, will take shafts from ½" to 1⅜" with proper size Taper-Lock bushings, and up to 2" without the bushings. Hubs are machined from bar stock and the one piece sleeve is made of steel. This design means a smaller, light weight coupling that is easier to install and maintain and yet can transmit the necessary power. Size 162, Series M gear couplings can be used for continuous operation up to 5000 rpm at torques up to approximately 2000 inch pounds.

WRITE FOR CATALOG

WALDRON Couplings

WALDRON-HARTIG DIVISION
MIDLAND-ROSS CORPORATION
BOX 791, NEW BRUNSWICK, N. J.

engineer with advancement to scientist or oblivion. —FRANK GREENHALGH
Fort Wayne, Ind

• A situation exists in industry in which some engineers or machine designers, if you will, simply function as memory-recall devices in assembling standard parts into a standard design. This, I feel, is wasting some of the skill of a competent and specially trained man who should be doing the work that a machine cannot do, namely, adding something of a basic concept or converting an idea into practical hardware. Our differences of opinion may be of definition. Perhaps you mean by "machine designer" what I mean by "engineer." I get this idea from your final paragraph which suggests that an engineer should advance himself to become a scientist.—EJT

COMING EVENTS

APRIL

23-25 . . . American Society of Mechanical Engineers, Metals Engineering Conference, Penn Sheraton Hotel, Pittsburgh

MAY

7-11 . . . . American Society of Mechanical Engineers, Engineering Institute of Canada, Hydraulic Conference, Queen Elizabeth Hotel, Montreal

8-9 . . . . American Society of Mechanical Engineers, Lubrication Symposium, Hotel Deauville, Miami Beach

8-10 . . . . Institute of Radio Engineers, 13th Annual National Aerospace Electronics Conference, Biltmore & Miami Hotels, Dayton, Ohio

9-11 . . . . Western Joint Computer Conference, Ambassador Hotel, Los Angeles

9-11 . . . . Institute of Radio Engineers, 1961 Electronic Components Conference

10-12 . . . . Society for Experimental Stress Analysis, Spring Meeting, Benjamin Franklin Hotel, Philadelphia

14-17 . . . . National Fluid Power Association, 1961 Spring Meeting, The Greenbrier, White Sulphur Springs, WVa

22-25 . . . . American Society of Mechanical Engineers, Design Engineering Conference & Show, Cobo Hall, Detroit

22-26 . . . . American Society of Tool & Manufacturing Engineers, 1961 Convention, Statler Hilton Hotel, NYC

For a listing of addresses of societies and associations send 25¢ to Product Engineering Reader Service Dept, 330 W 42nd St, NY 36. Ask for brochure R 32.

Gates Super HC Drives permit power increase of 20 hp in less drive space

The Daffin Feedmobile is a well-designed, efficient feed mill on wheels made by Daffin Manufacturing Co. of Lancaster, Pennsylvania. Originally, all the power for grinding, mixing and blending was transmitted by conventional V-belt drives.

Early in 1960, the machine was redesigned to obtain the competitive advantages that result through use of Gates Super HC High Capacity V-Belt Drives.

An official of the company, John Skinner, Jr., says: "The Gates Super HC Drives let us increase the output of the diesel power plant from about 100 HP to 120 HP without reducing the original safety factor. Sheaves are narrower and are about 80 pounds lighter, reducing the overhang load on bearings, increasing bearing life. Guards are 4 inches narrower, require less metal and are nearly 33% lighter weight. Drive cost for each machine has been cut 7 or 8%."

He says further: "The Gates High Capacity Drives have greatly strengthened one of our most important selling points—the fact that 'there is far less down-time with a Daffin.'"

Manufacturers everywhere have standardized upon the Gates Super HC V-Belt Drive—the first and most advanced high capacity drive. It is your best assurance that your power transmission unit will not soon become obsolete.

The Gates Fieldman located near you is a drive design expert. Contact him for technical information and assistance in designing Gates High Capacity V-Belt Drives.

The Gates Rubber Company, Denver, Colorado

BP 15D

Exclusive design features include:

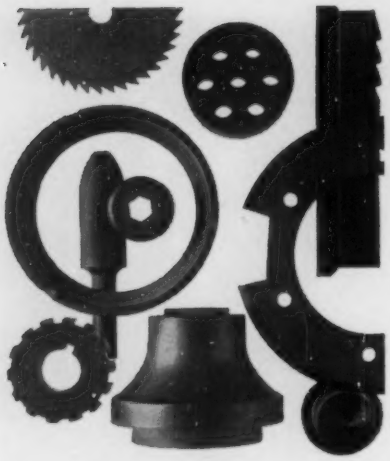
precisely engineered arched top, concave sidewalls, Flex-Weave cover, super strength tensile construction.

Gates Super HC Drive saves space, weight and money

Gates

Building the future on 50 years of progress.

Gates Super HC V-Belt Drives



All these parts were problems until made of KENNAMETAL*

Made of Kennametal and Kentanium,* these parts perform better, longer. Punches, dies, seal rings, nozzles, pump parts, temperature sensing elements, and many other critical parts are custom-engineered to solve specific design and materials problems.

OUTSTANDING PROPERTIES

- Extremely high rigidity (YME up to 94 million psi, compared with steel's 30 million).
- Density of compositions from 5.7 to over 15.0 gms/cc, compared to steel at 7.8.
- Compositions to resist corrosion-wear conditions encountered with nitric, sulfuric, and hydrochloric acids, and sodium hydroxide.
- Kennametal is extremely hard (up to 94 Rockwell A) and outwears steel as much as 100 times.
- Kentanium retains sufficient strength for continuous operation up to 2200°F and at higher temperatures under specific conditions.

There is a good chance that one or a combination of the unique properties of Kennametal and Kentanium can solve some of *your* problems.

For further information, contact your Kennametal Representative or write us direct for Booklets "Properties of Kennametal" and "Proven Uses of Kennametal and Kentanium." KENNAMETAL INC., Department PE, Latrobe, Pennsylvania.

*Kennametal is the registered trademark of a series of hard carbide alloys of tungsten, tungsten-titanium, and tantalum. Kentanium is the registered trademark of a series for applications requiring a lighter weight material, or maximum resistance to temperature extremes. 34221

INDUSTRY AND KENNAMETAL ...Partners in Progress

FOR YOUR INFORMATION (personal)

Stickum stick

A single-component epoxy adhesive in stick form is to be marketed for home use by Cetron Electronic Corp. The company says it's the same composition developed for printed circuit applications (see photo), will adhere permanently to metal, ceramics, wood, glass, textiles, and plastics. The material is solid at room temperature, softens at 105 to 120 F, spreads at 200 F. For industrial applications, the parts to be bonded are heated, and then cured. Cure time depends on temperature, ranging from 7 min. at 420 F to 12 hr at 245 F.

Help for the home painter

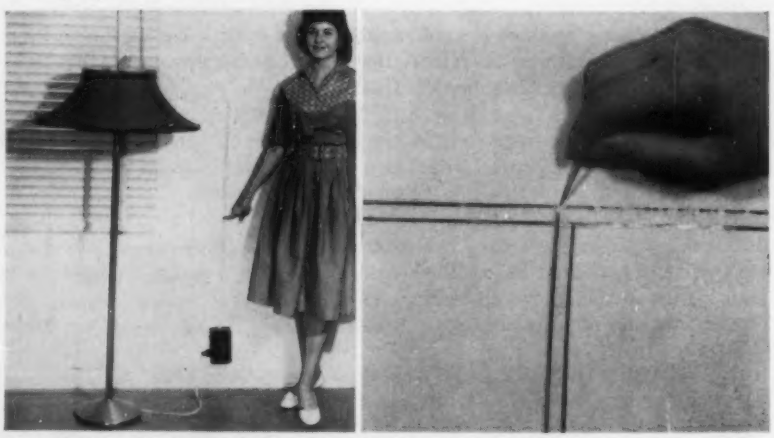
A paint that will even coat uncured concrete, and another that's virtually fool-proof for interior work, are among the new products to aid your spring-time spruce-up. Both are acrylic-based water emulsions. The first, a silicone-acrylic combination developed by Canadian Everguard Coatings Ltd, and now being licensed for US production, is said to form a waterproof yet "breathable" coating "on any building material, old or new." Everguard calls it "Betonite." The second is a US product, developed by DuPont, and now being introduced as "Lucite" paint. It has a thick, creamy, thixotropic consistency that makes it practically drip-proof and ensures a thick, smooth coating with brush or roller.

Just touch to switch

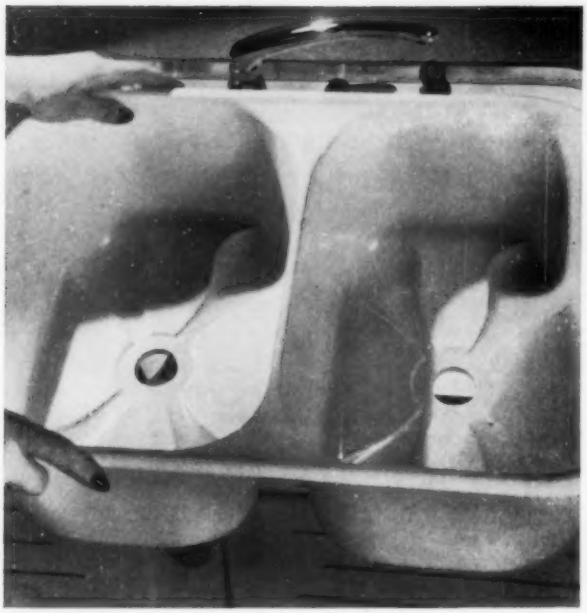
An "electronic switch" that makes it possible to turn a light or appliance off from a remote location with just a touch of the fingers has been developed by Gardiner Electronics Co, Phoenix, Ariz.

The system consists of a control box into which the lamp or appliance being controlled is plugged, plus pressure-sensitive tape carrying a pair of fine electrical wires. Plug the box into the wall outlet, run the tape as desired, and then, bridge the conductors with a finger to turn the light on or off.

Gardiner says the current in the conductors is so small there's no danger, and the circuit can be protected from accidental activation by covering the wires with clear tape. The unit, with 36 ft of tape, and silver paint for making splices, costs $58. —ARG

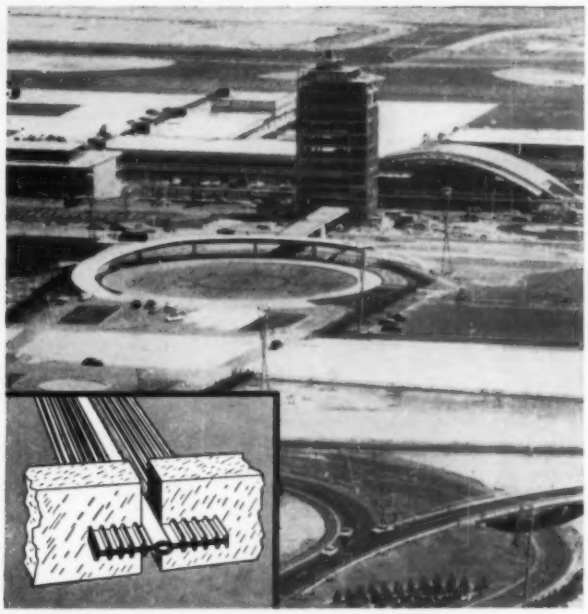


CONTROL BOX AND TAPED CONDUCTORS are essential parts of new electronic switch. Touching tape at any point turns lights on or off. As photo at right shows, conductors can easily be joined.



PROBLEM: IMPACT STRENGTH, *with acid, alkali and heat resistance* – Lightweight, one-piece, dual-compartment sink trays vacuum-formed from BAKELITE high-impact styrene offer housewives and photo developers the convenience of two identical basins in a single sink area. Available in white and colors, they are easy to keep clean and withstand bleaches, common acids, detergents and photo developing solutions. Weighing only 1½ lbs., the tray has a low unit cost.

The manufacturer of this patented dual sink insert, Goodhousewares Products Company, Los Angeles, Calif., chose extruded sheets of BAKELITE high-impact styrene only after other plastics were tested and failed to withstand "daily-use" tests.



PROBLEM: WATERTIGHT JOINTS *that are flexible* – The tough flexible waterstop extruded from a BAKELITE Brand elastomeric vinyl plastic compound stops moisture penetration through the joints in concrete walls and floors in the new buildings at International (Idlewild) Airport, N. Y., N. Y. This multiple ridge waterstop or joint membrane is inserted in the construction forms prior to pouring as a joint barrier. The lifetime flexibility of BAKELITE vinyl virtually assures against leakage due to fatigue, breakage, oxidation or chemical deterioration. Electrovert Inc. manufacturers of this "Durajoint" waterstop pioneered this application of plasticized vinyl. They have always specified BAKELITE Brand vinyls for all waterstop extrusions.

Extruded plastics for solving design problems

PROBLEM: DIMENSIONAL STABILITY, *plus good looks and toughness* – The spare tire cover of Ford Motor Company's "Comet" and "Falcon" station wagons is designed to be an integral, though removable, part of the interior body and decor. Thus, excellent dimensional stability is needed to avoid shrinking and warping despite rough handling or changing seasonal temperatures.

Extruded sheets made from BAKELITE Brand high-density polyethylene and vacuum-formed to exact dimensions were chosen for this application. In addition to stability and ease of fabrication, BAKELITE high-density polyethylene is light in weight, with excellent rigidity, toughness, heat resistance and stress-cracking resistance. And, it is available in a wide range of colors. Remember, too: there's variety in BAKELITE polyethylene – with low-, medium-, and high-density formulations. You can use our broad experience to find out which meets your needs best.

Here's how other design engineers used them to solve problems of cost and performance

Take a look at the various products pictured here . . . study the design problems of each . . . see how all were effectively solved. Do you find some similarity between these and your own design problem?

A particular BAKELITE Brand resin may be just the plastic you need. You have a wide range of choice – polyethylenes, epoxies, phenolics, styrenes, vinyls – all of traditionally high UNION CARBIDE quality. See your Sweet's Product Design File, Section 2a/ui, for properties. Or, for more detailed information, just mail the coupon.

UNION CARBIDE

BAKELITE and UNION CARBIDE are registered trade marks of Union Carbide Corporation.

Dept. JJ-113D, Union Carbide Plastics Company
Division of Union Carbide Corporation
270 Park Avenue, New York 17, N. Y.

Please send me information on BAKELITE resins and suggested applications. I am especially interested in

_____

NAME _____

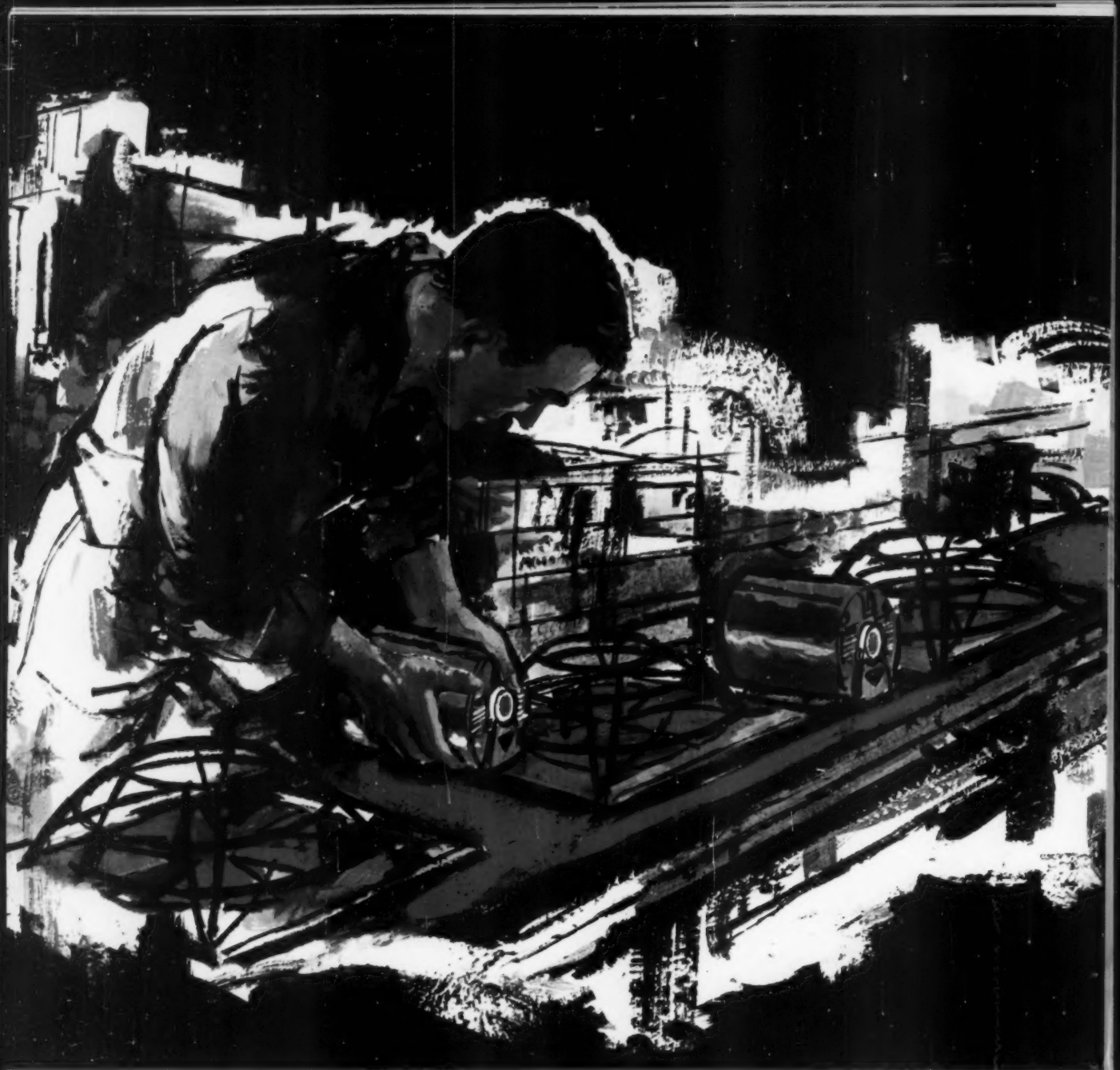
FIRM NAME _____

STREET _____

CITY _____ ZONE _____ STATE _____

CIRCLE 33 ON READER SERVICE CARD

CIRCLE 34 ON READER SERVICE CARD →



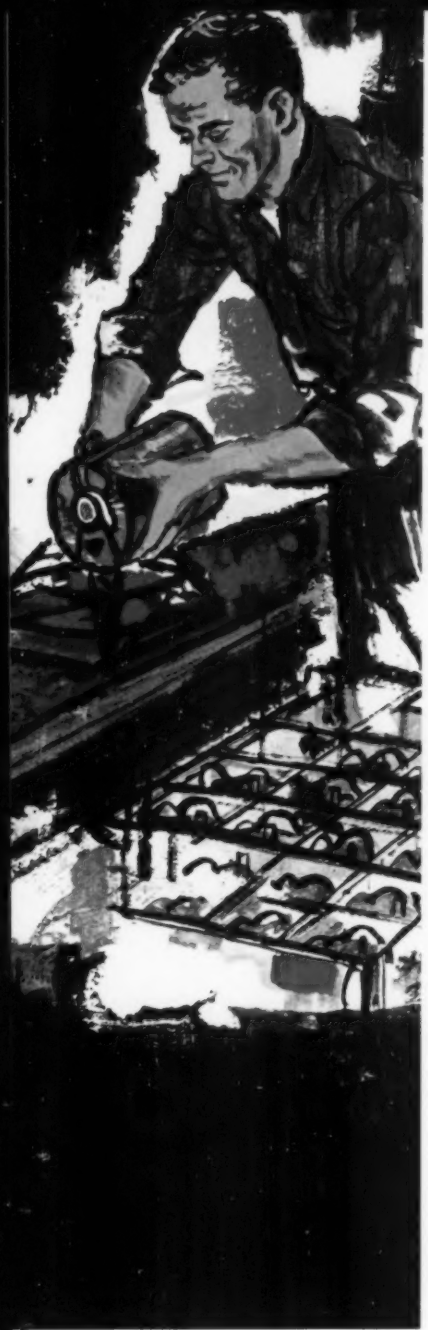
You get **MORE THAN A MOTOR** with
General Electric's Form G . . . for example . . .

Ease of Assembly

Fast, easy assembly is an unchallenged virtue of the General Electric Form G fhp motor. Mount it in a few minutes. Hook it up in seconds.

Count on savings in both installation time and costs. And . . . rest assured you're including the best fhp motor that money can buy.

In addition to fast assembly on your product, you get these MORE THAN A MOTOR benefits with General Electric Form G motors: *Years-ahead Design Leadership . . . Expert Application Aid . . . Versatility Personified . . . On-time Delivery . . . Fast, Local Service.*



THESE YEARS-AHEAD FORM G MOTOR FEATURES SPEED ASSEMBLY, CUT SHIPPING COSTS

1. EASY TO HOOK UP—An enlarged wiring compartment and a clean terminal board give you greater accessibility; speed connection; save you assembly-line time and money.

2. FAST CONDUIT CONNECTION—A special speed nut, welded inside the motor shell, permits conduit connection from outside; makes hookup fast, easy; simplifies motor installation.

3. FAST LEAD CONNECTION—Quick-connect wiring tabs on all external and internal terminals cut wiring time in half. Simply plug in leads for fast, easy, positive connections.

4. SAFE, SIMPLE GROUND—A built-in grounding lug on General Electric Form G motors permits fast, easy grounding of a third lead (when required) to meet UL standards.

5. COMPACT, LIGHTWEIGHT—Up to 50% lighter, 40% smaller than old-style motor designs, Form G motors cost less to handle, install and ship; cut down assembly-line fatigue.

6. ALL-ANGLE OPERATION—All-angle sleeve bearings and positive oil retention system allow you to mount standard Form G motors in any position. No need for costly specials.

These *added values* can be yours at no extra cost. So why settle for less? Form G fhp motors are available in NEMA 48 and 56 frames. For more information, call your G-E Sales Engineer or write for bulletin GEA-6424 to Section 721-09, General Electric Co., Schenectady 5, N. Y.

Progress Is Our Most Important Product

GENERAL ELECTRIC

the LEAD newsletter

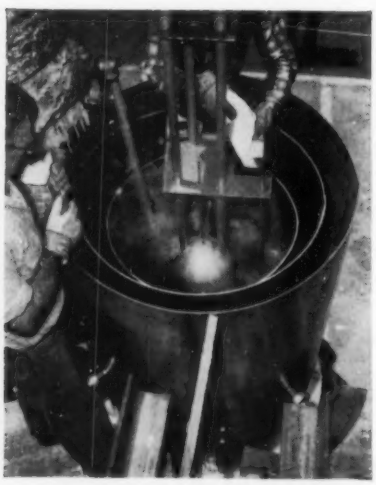
Vol. 3 No. 1

The use of lead to save weight is increasingly demonstrated by imaginative designers and engineers in many fields. They have often achieved the lowest total weight in their designs by taking advantage of lead's density. At 11.34 g or more per cc, depending on whether cast, rolled, or extruded, lead's density is the highest among the common, low-cost, commercial materials.

Lightweight Reactor Shielding

The effectiveness of lead in saving space when used for protective shielding against gamma- and X-radiation is known to everyone. Not recognized by many is the fact that a shielding of lead, when properly designed, is also usually lighter than other shielding materials. Increased thicknesses required for efficient shielding by other materials disproportionately increase the bulk of the shield.

The space/weight savings possible with lead are especially important, often critical, in reactors used to power ships and other forms of transportation, portable power plants, laboratory reactors, and the shielding of shipping containers.

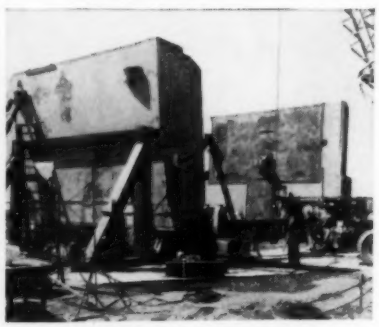


Technicians installing lead shot shielding in laboratory reactor.

Lead in shot form has the added advantage of handling ease when used in reactor design. Poured into the space allowed for shielding, it packs into every crevice, molds itself to wall contours without vibration, and may be drained off or replaced almost as readily as water.

Recommended for further reading on the subject is the booklet "Materials for Portable Nuclear Reactors," available on request from Lead Industries Association.

Smaller Counterweights Do a Bigger Job



Missile silo doors during construction at Vandenberg Air Force Base.

Because of its density, lead is widely used for making counterweights of many kinds. They range from the common small weights for balancing auto wheels to the huge weights, requiring altogether 10,000 tons of lead, used to balance the elevators and steel and concrete doors of the Titan missile launching system.

Lead weights obviously can be smaller than those made of materials of a lower density. Interestingly, weights required to do a given job can frequently be lighter when made of lead. Because lead weights are more compact, they can be concentrated at much greater distances from the fulcrum, where they have a greater counterbalance force.

In lead's favor is the ease with which it can be fabricated, by casting, extrusion, or rolling, to fit irregular spaces, or to form unusual shapes effecting maximum effectiveness at lowest weight. Where the use of heat casting is not desirable, the advantages of lead may still be realized through the use of lead wool, lead shot, or molded lead-impregnated plastic.

In Munitions Lead Unrivalled

A time-honored use of lead is the manufacture of ammunition. Here, too, the major factor that dictates its choice is density. It permits attainment of the high velocity required for maximum striking power and accuracy. The smaller surfaces required for a given weight reduce air resistance.

Lead Saves Space and Weight In Noise Barriers

In noise barriers such as partitions, the weight and limpness of lead produce savings in space and weight. Because of lead's high density, heavier partitions can be built in smaller spaces, increasing usable floor space. This combination of density and limpness means that partitions incorporating lead may be lighter in total weight yet be equal or better in sound-deadening effectiveness than partitions of other materials. The superiority of lead is technically detailed in "Improved Sound Barriers Employing Lead," available on request.

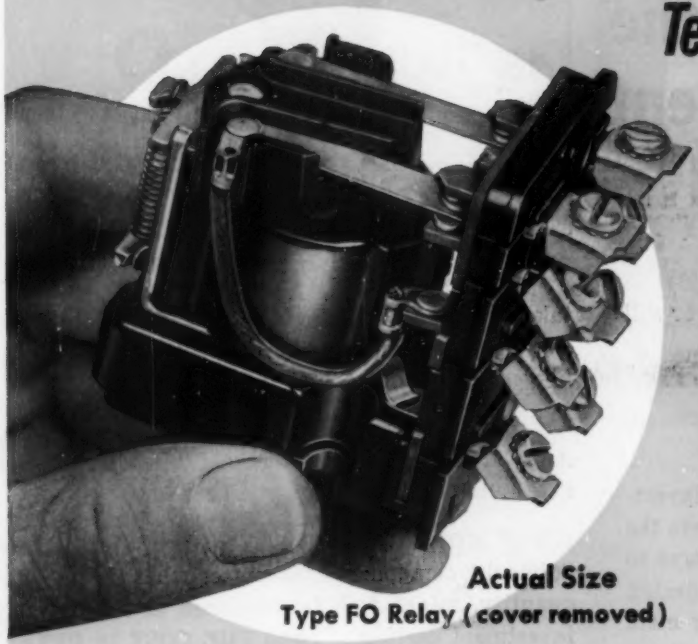
Through continuous research by L.I.A., lead and its many compounds are keeping abreast of changing technology. For technical information or assistance on new products or problems where lead's unusual capabilities may be of value, simply write: Office of Technical Information, Lead Industries Association, 292 Madison Ave., New York 17, N.Y.

4478

LOOK AHEAD WITH LEAD

NEW from Square D...

A SMALLER 10 AMP RELAY— WITH INDUSTRIAL FEATURES!



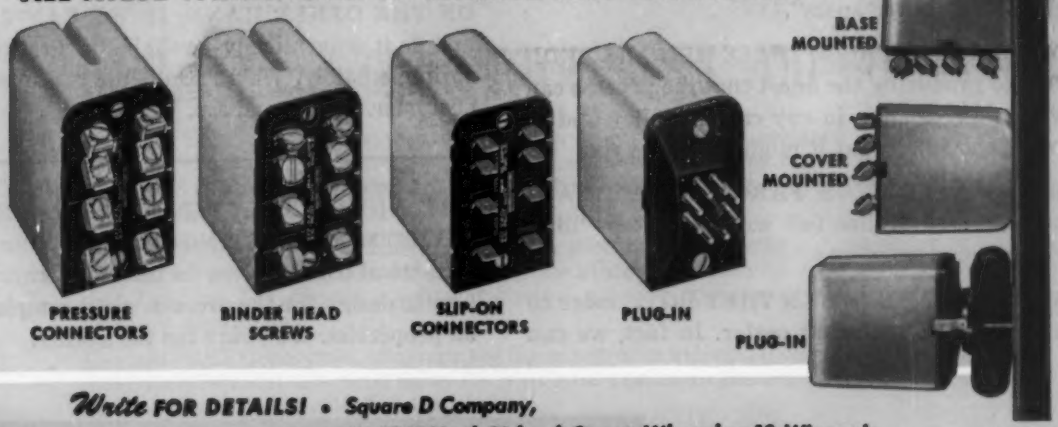
Actual Size

Type FO Relay (cover removed)

Terminal or Plug-In Wiring

- **RATINGS** easily handle solenoid loads. AC pilot duty rated 690 VA. Continuous rating 10 amperes, 125 volts AC for plug-in construction and 277 volts AC for terminal connection
- **Long Life** makes suitable for rugged machine tool applications
- **Molded coil** operates cooler and keeps out moisture for longer life
- **No solder joints** to break
- **Optional pilot light** indicates when relay is energized
- **Durable nylon dust cover** won't break, crack or support combustion

ALL THESE VARIATIONS OF WIRING AND MOUNTING



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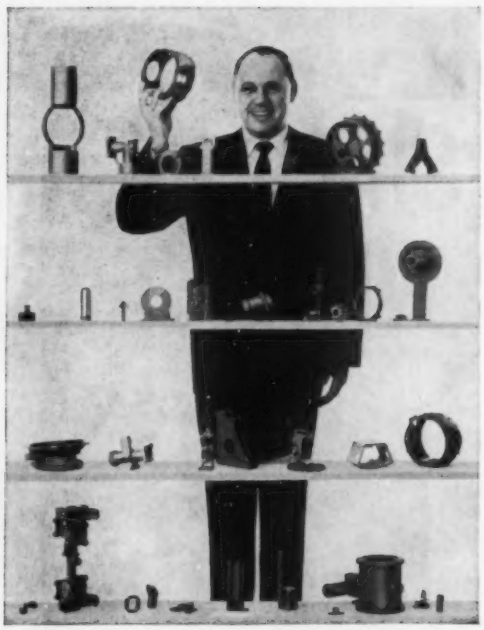
SQUARE D COMPANY

wherever electricity is distributed and controlled

CIRCLE 37 ON READER SERVICE CARD 37

Because we've always welcomed "little" jobs, too–

We've become the biggest in the investment casting field...



No investment casting job has ever been or ever will be too small for us.

WE DON'T HAVE ANY "SIDELINES," nor is investment casting only a sideline with us. It is the "be-all and end-all" of our economic existence.

AS A RESULT: anybody who thinks that an investment casting will help him solve a problem gets the unqualified, attention of the top talent we have to offer–from our trained field engineers, our design engineers, our estimating staff, our tooling men, and our production specialists. No one of these groups cares whether your order is for 50 parts or 100,000. If they accept the order, they want it handled to or above "specs".

WHY? SIMPLY BECAUSE THESE MEN ARE DEDICATED to producing the finest that the process can deliver in any design, in any castable alloy and in quantities so small that it might surprise you.

THEIR ATTITUDE IS FAR FROM PHILANTHROPIC; they realize full well that your "little ones" may soon grow up.

ARWOOD IS READY WHEN THEY DO ... more so than any other investment caster. In fact, we can take in stride all the volume that's required. Our five plants, each fully integrated can handle the biggest job you can offer.

ONCE THE PROTOTYPE PHASE IS COMPLETED, Arwood can give you the quantity production you need, and deliver it when you need it.

WHAT MORE CAN WE SAY? Simply this. Most "difficult" components, no matter what the alloy or quantity, might well be produced as an Arwood investment casting ... and THE COST IS OFTEN EXTREMELY LOW, compared with conventional methods.

ON THE OTHER HAND, IF WE CAN'T DO IT– and do it economically–we'll be the first to tell you so immediately. We'd rather lose an order than a customer. Try us and see.

ARE YOU REALLY UP-TO-DATE ON WHAT INVESTMENT CASTING CAN DO? Our 48-page "Practical Guide" gives forthright answers ... tells how to design for the process, gives complete tables on properties. It's yours for the asking.

Machine the simple ... cast the complex

A complete service from design through tooling, production and finish machining. Seventy-one engineering representatives from coast to coast.

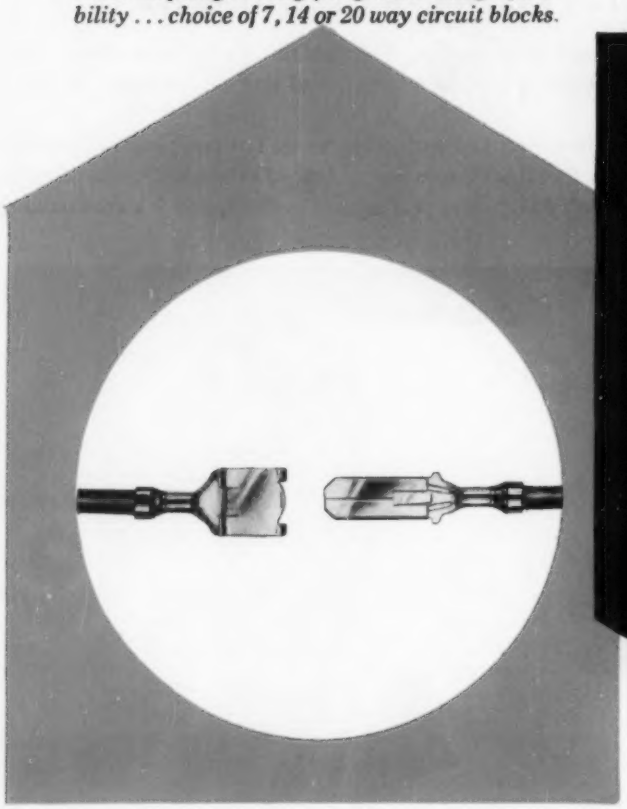
arwood

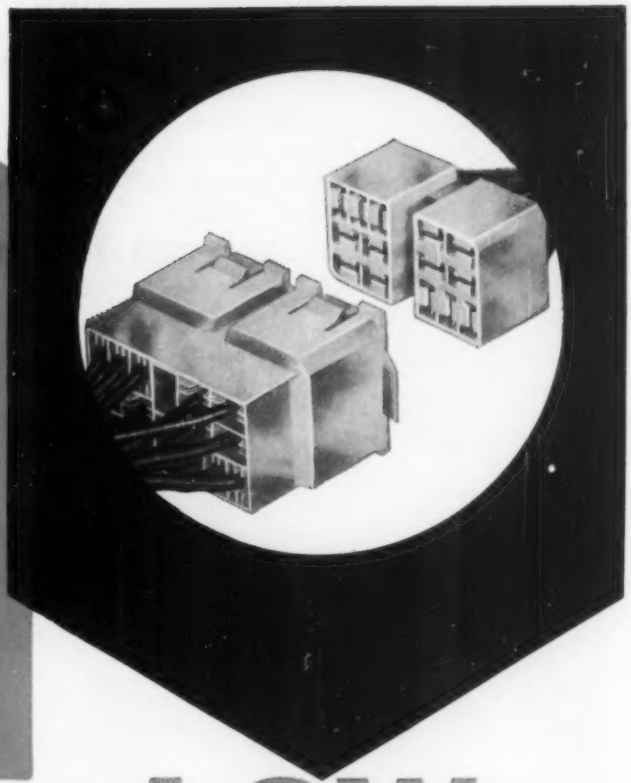
ARWOOD CORPORATION • **325 West 44th Street, New York 36, New York**

PLANTS IN BROOKLYN, N. Y.; TILTON, N. H.; GROTON, CONN.; LOS ANGELES AND LA VERNE, CALIF.

HIGH

20-25 amperage rating for greater design flexibility . . . choice of 7, 14 or 20 way circuit blocks.





LOW

2-5 pounds insertion and extraction force for easier installation and servicing.

NEW AMPEEZ CONNECTOR GIVES YOU BOTH

Here is a workhorse of a connector! Housed in tough nylon and designed to carry as many as 20-circuits while holding insertion-extraction forces to 2-5 pounds, AMPEEZ Connectors are adaptable to many applications calling for a heavy-duty, easily serviced multiple-circuit disconnect.

AMPEEZ Connectors will match your application needs perfectly . . . anything you call for up to 20-circuits and 25 amps. One other major feature! *AMP's exclusive Tab-Gap Lok assures a constant contact pressure even under the severest vibration conditions.*

Use AMPEEZ Connectors, eliminate the human error in individual connections . . . make them fast and safe. Send today for AMPEEZ Connector literature and sample of tab and receptacle with Tab-Gap Lok.

AMP INCORPORATED

GENERAL OFFICES: HARRISBURG, PENNSYLVANIA

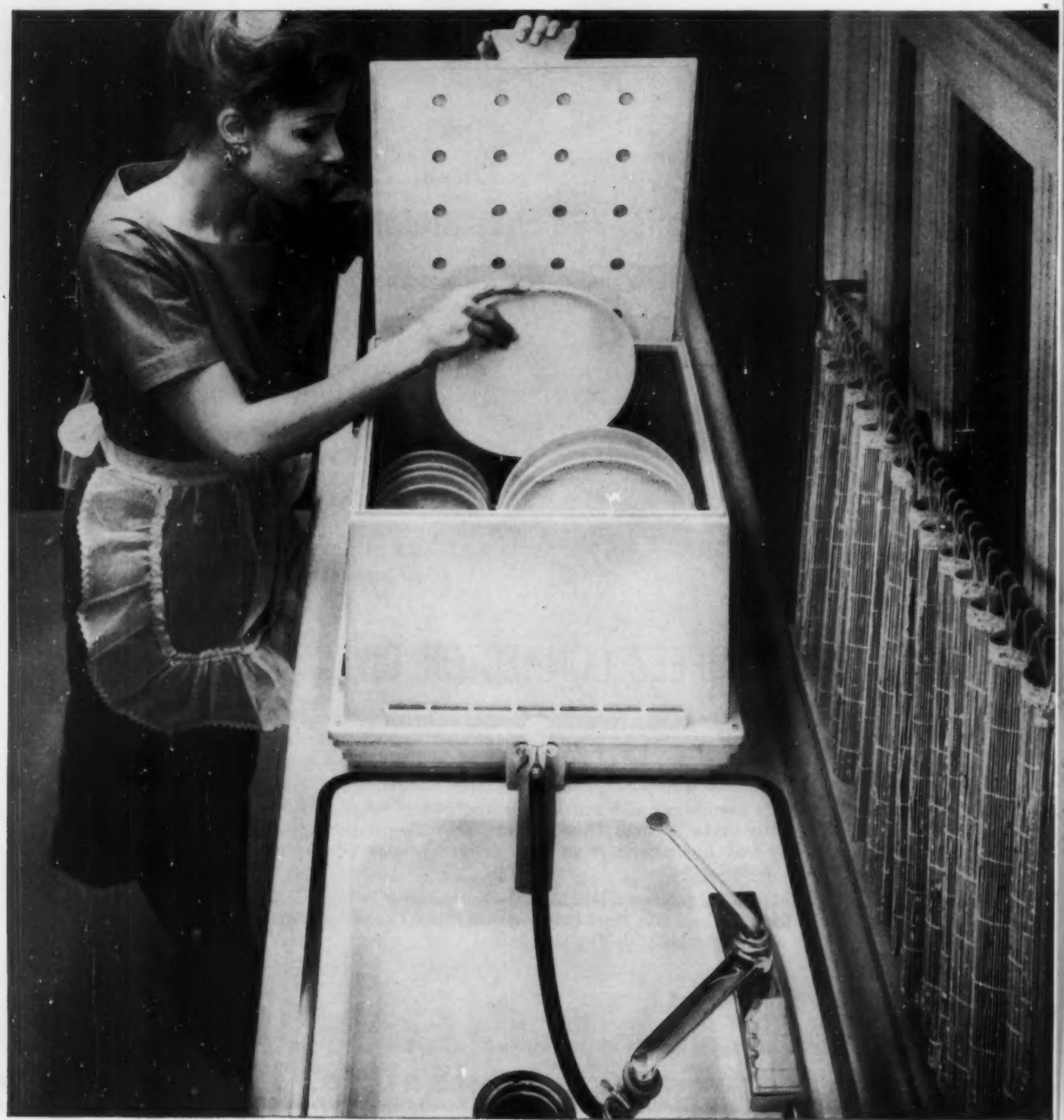
AMP products and engineering assistance are available through subsidiary companies in: Australia • Canada • England • France • Holland • Italy • Japan • West Germany

CIRCLE 39 ON READER SERVICE CARD

Portable dishwasher powered by kitchen tap

This 11-pound, portable dishwasher developed by Spaulding Industries, Inc., Chicago, Illinois, needs no power other than water pressure from a tap. Just set it on the sink, attach its hose to a faucet, and turn on the water. It washes and rinses completely in only 6-8 minutes.

The base, case and lid are molded from heat-resistant, high-impact DYLENE® polystyrene. The one-piece DYLENE base and lid have intricately molded vents that circulate cool air that dries dishes in a matter of minutes. DYLENE plastic is easy to mold in any permanent color, size or design. It won't flake, chip, peel or mar surfaces, and it's unaffected by harsh detergents and scalding hot water.



Foam plastic liner muffles disposer noises

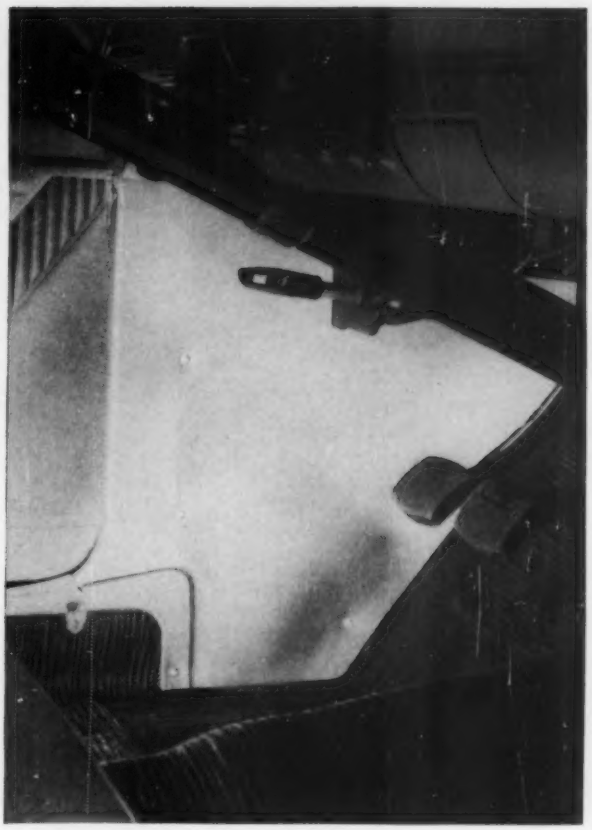
Designers at In-Sink-Erator Manufacturing Company knew they could increase sales of this new Gold Comet garbage disposer if they could make it work quieter. So they placed a molded liner of DYLITE® expandable polystyrene inside the unit. This rigid foam plastic muffles noises as the unit shreds food wastes down the kitchen drain.

DYLITE is strong, lightweight, water and vapor-resistant. It can be molded to almost any size, shape or color. This low-cost plastic is ideally suited for a wide variety of applications in protective packaging, low temperature insulation, flotation and refrigeration. DYLITE parts molded by: Stevens Plastics Products, Hebron, Illinois.

Trash cans that won't rust, rattle or corrode

Because it's polyethylene, these trash cans resist acids, alkalies, rust and corrosion, and even rough handling won't dent, chip or peel them. They're molded from durable DYLAN® polyethylene and available in beautiful permanent colors. Each trash can has a molded lid that locks tight and prevents spilling.

Koppers has a wide range of polyethylenes for almost any application. They are available in densities ranging from .914 to .953 gm./ml. By varying density, molders or design engineers can get varying degrees of stiffness, heat distortion and tensile strength. Trash cans molded for Sears Roebuck by G. A. T. X., Chicago, Illinois.



Plastic side cowls protect car interiors

Ford Motor Company now uses SUPER DYLAN® high-density polyethylene for interior side cowls on all their Falcon, Comet, Mercury, Thunderbird and Ford models. These cowls have replaced painted hardboard and fabric lacing. They last longer, look better, install easier.

SUPER DYLAN side cowls won't scuff, crack, chip or peel. They won't absorb water so they don't warp or discolor. Temperature changes won't bother them. They're easy to clean and their colors are built-in to last the life of the car.

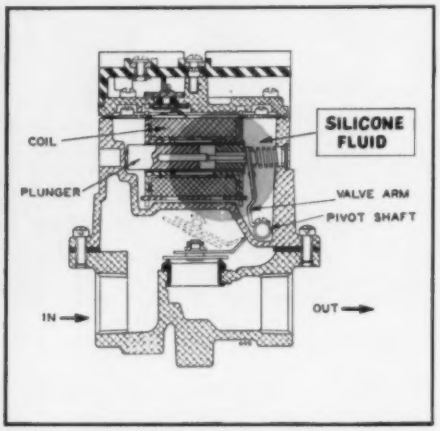
KOPPERS PLASTICS

KOPPERS®

Find out how Koppers family of fine plastics can help improve your product at less cost to you. For more complete information, contact Koppers Company, Inc., Plastics Division, Dept. 1515, Pittsburgh 19, Pennsylvania.

SILICONE NEWS from Dow Corning

For Designs That Perform



SILICONE DAMPED CONTROL VALVES

New Fluids Assure Accuracy

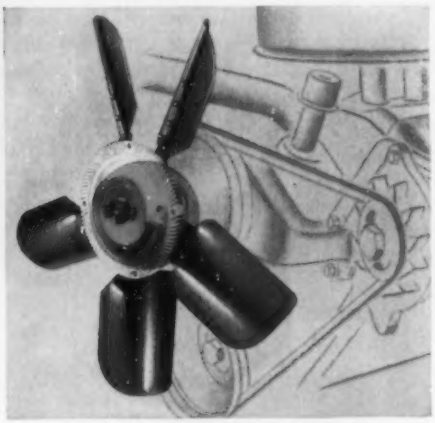
Here's why Dow Corning silicone fluids improve performance of mechano-fluid devices and controls. They maintain near-constant viscosity over a wide temperature span; exceptional resistance to oxidation and to breakdown due to shear; and fine dielectric properties. In service, these silicone liquids don't sludge or gum; don't corrode metals nor cause rubber to swell.

Uniform Damping From the arctic to the tropics, behavior of Dow Corning silicone fluids remains virtually constant. As indicated by performance in a torsional vibration damper, damping effect of silicone fluid decreases in the ratio of 3 to 1 over a temperature range from —40 to 160 F; a petroleum hydraulic fluid decreases in the ratio of 2500 to 1.

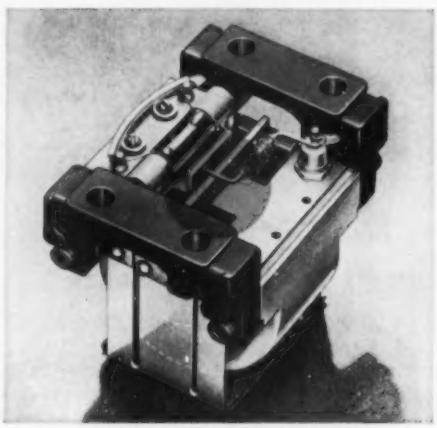
Damping Medium	Pounds of Damping Force Required to Actuate Against Viscous Drag	
	at —40 F	at 160 F
Dow Corning 200 Fluid 30,000 centistoke grade	210	70
Petroleum Hydraulic Oil (Very high viscosity)	70	0.028

Compressibility Too Formulated to retain its desirable characteristics and also have good compressibility at high pressures, a silicone fluid for "liquid springs" for aircraft landing wheels makes possible a 30% smaller oil chamber; assures uniform performance over wide temperature range.

Aid to Miniaturization The near-ideal silicone fluids also help to reduce size and weight of accelerometers, fan drives, radar buffers, differential pressure cell transmitters, panel instruments and truck scales.



SILICONE COUPLED FAN DRIVES



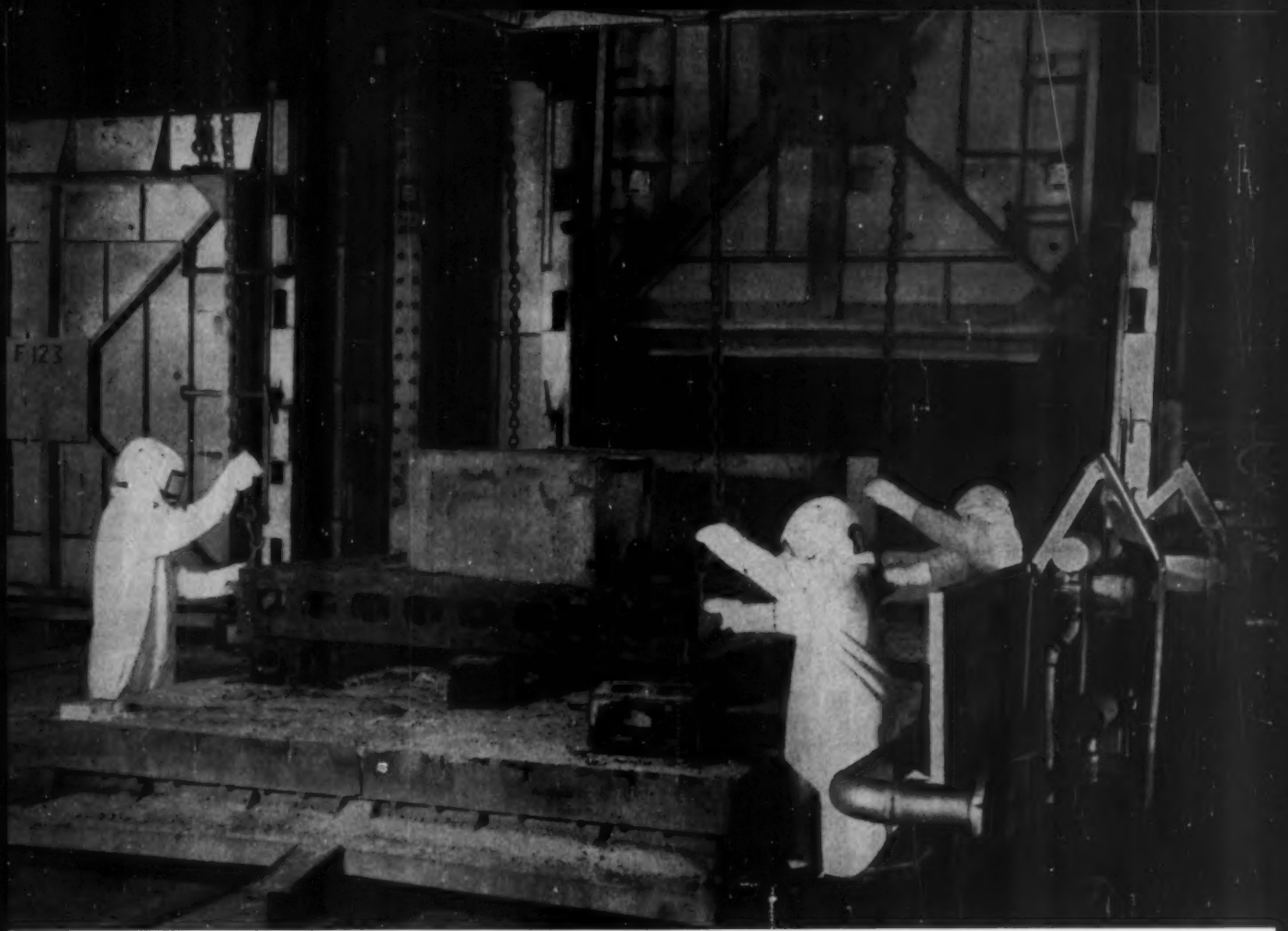
SILICONE DAMPED ACCELEROMETERS

For more information about silicones and their use in mechano-fluid devices, contact the Dow Corning office nearest you, or write Department 7216a.

first in silicones

Dow Corning CORPORATION
MIDLAND, MICHIGAN

ATLANTA BOSTON CHICAGO CLEVELAND DALLAS LOS ANGELES NEW YORK WASHINGTON, D. C.



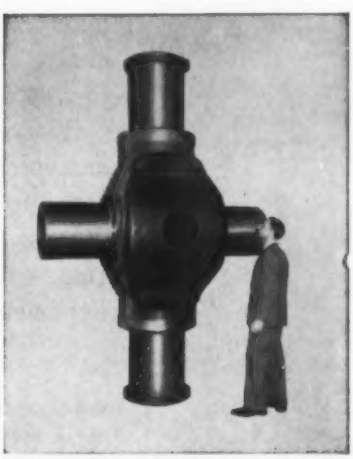
Blaw-Knox Steel Foundries have the heat treating capacity to handle the largest casting

Your steel casting gets precisely the characteristics of uniform hardness, toughness, or temper you specify in a Blaw-Knox Steel Foundry. Blaw-Knox Steel Foundries are equipped with huge pit-type furnaces—some as large as 42 feet × 20 feet × 13 feet deep, and banks of car type furnaces to accommodate the largest steel casting or batches of smaller ones.

Quench tanks as large as 21 feet × 12 feet and 8 feet deep are available, and all Blaw-Knox Steel Foundries are equipped for spray quenching in which specific areas of steel castings are given special quenching. Further flame hardening or other hardening procedures are provided to meet your exact requirements.

Complete heat treating, quenching, and hardening is another way in which Blaw-Knox Steel Casting Service adds value to your product. Blaw-Knox, as one of the world's leading rolling mill and industrial machinery builders, keeps a sharp eye on the end-use requirements of a casting from start to finish. It's your assurance of a component of the highest quality, made for maximum service.

If you design or build products using cast steel components, ranging from 50 pounds to 300,000 pounds, Blaw-Knox would like you to have a copy of our brochure detailing Blaw-Knox Steel Castings Service. Write to the Foundry and Mill Machinery Division, 300 Sixth Avenue, Pittsburgh 22, Pennsylvania. No obligation of course.



This main axle casting for the 60-cubic yard Mountaineer Shovel was cast in a Blaw-Knox Steel Foundry. Wt.—18,000 lbs.

BLAW-KNOX

Steel Castings

CIRCLE 43 ON READER SERVICE CARD

1961 DESIGN ENGINEERING

and Concurrent ASME Conference

Put those important product drawings and specifications in your briefcase. Make a list of original equipment you want to know more about. Get a big notebook, and pack a pair of comfortable walking shoes. Then head for Detroit's magnificent new Cobo Hall and the biggest, most exciting Design Engineering Show in history.

The best design and development work that over 350 companies can come up with is ready for you to see, compare, and study. The top application engineers of these companies will be on hand to discuss their products with you – go over drawings and specifications – make suggestions – offer you the benefit of their cumulative experience.

SHOW COBO HALL Detroit · May 22-25

Everyone with design-engineering responsibility will benefit from DESIGN WEEK IN DETROIT – and every company will profit by *making sure* its design-responsible executives and engineers have this once-a-year chance to see the latest and best in original equipment. There are three mornings and evenings of concurrent ASME Conference sessions waiting for you, too – all devoted to "*Designing for the Competitive Market*". There is much for you in every one of the Conference's 24 major papers.

For hotel reservations write the Detroit Convention & Visitors Bureau. For other information contact:

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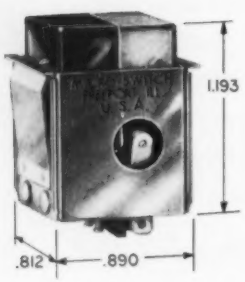
MICRO SWITCH Precision Switches

FULL COMMAND IN ONE CUBIC INCH!



NEW MINIATURIZED LIGHTED PUSH-BUTTON SWITCHES SAVE PANEL SPACE

The new "302PB" Series combines control and visual indication in one completely assembled unit that requires less than one cubic inch of panel space. These miniaturized lighted push-button assemblies can be mounted or removed without tools.

The display screen, mounting flanges and two single-pole double-throw basic switches are all integral components, permanently assembled to make a mechanically strong unit built for long life. Fifteen display screen color combinations are available, obtained by use of a split screen. A separate miniature lamp illuminates each half of the screen. These lamps are designed for infinite service life. "302PB" Series switches conform to the applicable requirements of MIL-S-6743, MIL-S-6744 and MIL-E-5272A. Check the nearby MICRO SWITCH Branch Office, listed in the Yellow Pages for full information or write for Data Sheet 182.

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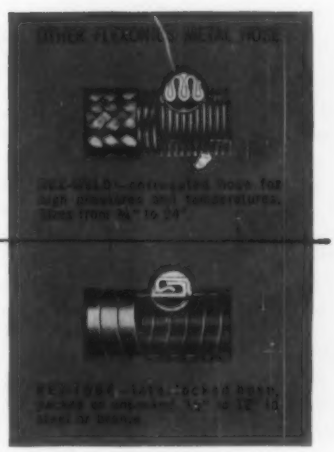
Flexonics Hi-Flex is a new, *all-new* corrosion-resistant, helically-formed metal hose. It is new in design, new in method of tube forming, new in manufacture . . . and it is subjected to the most rigid quality control. Hi-Flex hose is your answer for cryogenic applications, where cleanability, high pressures, and wide temperature ranges are critical . . . for hydraulics and pneumatics, where pressures and flexibility are design criteria . . . and for many other demanding aeronautical, missile, and industrial applications.

Hi-Flex hose is available for low, medium, and high pressures, in sizes from ¼" through 1¼". Mail coupon for copy of new Catalog 200E.



IH-465

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Gentlemen:
Please send me a copy of your new Catalog 200E, on Flexonics Hi-Flex Metal Hose.

Spaulding **FIBRE FACTS FOR ENGINEERS** NUMBER 4

How to Punch Vulcanized Fibre to Reduce Fabrication Costs

by K. H. Alwerson, Product Standards Director

Vulcanized Fibre's capacity for easy punching makes this material highly attractive to the designer whose application calls for characteristics such as good dielectric strength, light weight, rugged strength, irregular contours and holes and indentations in the surface of a part.

Punching is done with two kinds of precision: Rough punching uses the lowest cost solid dies, is rapid and economical, but leaves a fractured raw edge and is limited to stock thicknesses through ¼ in.; smooth shaving uses a contour die ground to a sharp edge that slopes away at 45°. The edge shaves stock when the part is forced into the die producing smooth edges in parts up to 1 in. thick. Holes can be punched easily, but should be generally spaced from each other and from any edge by at least the thickness of the stock. Noncircular holes and counterbores should be made circular for machining when the stock thickness specified is too thick to punch.

For thickness under 3/64", vulcanized fibre can be punched most economically with steel rule dies. Dies for simple parts usually cost much less than solid dies even for irregular contours. Tooling for scoring or creasing can also be added with little additional cost.

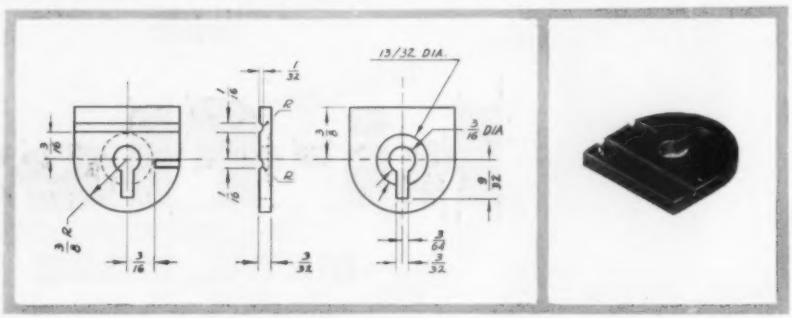
Most parts can be punched without additional conditioning if the vulcanized fibre has its normal moisture content of 5½ to 7%. For especially difficult punchings, or for parts thicker than ⅛", heating up to 200°F may be desirable.

Additional economies may be obtained in thicknesses 1/16" and under by using coils slit from parent rolls, reducing waste of stock, speeding up the punching operation, and reducing inspection costs.

Many extras may be incorporated in punching operations on vulcanized fibre. These include scoring or creasing for subsequent forming along established lines. Also practical are swaging or forming into special shapes, such as shoulder bushings or angles.

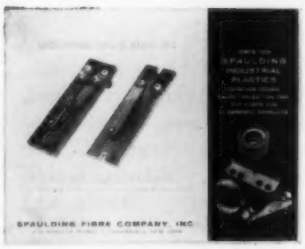
Stamping letters and numerals into the surface of vulcanized fibre in the punch-press operation produces permanently legible markings with no increase in cost of the part. White or colored roll leaf characters can also be impressed into the surface to give color contrast at very little added cost. Punched parts are also readily printed with rubber stamp.

Spaulding Engineers who have been trained in Value Analysis can help you take advantage of the wide range of possibilities in designing to reduce costs through the use of vulcanized fibre parts. They also make available to you Spaulding's extensive fabricating facilities and experience in working with this extraordinary material.



The fabrication of this shut-off switch insulator demonstrates vulcanized fibre's facility for punching and swaging. Previously moulded out of nylon, the part is now made by swaging both sides and punching vulcanized fibre — all in the same operation and at lower costs both for material and processing.

Send for your FREE copies of this literature



Value Analysis Brochure — case histories of design improvement and cost reductions that have been accomplished through Spaulding's value analysis of customer products.

Vulcanized Fibre Engineering Data — a design reference book which comprehensively covers all the application specs of vulcanized fibre.

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New space-saving Cleveland motorized Speed Variator

Now, for either OEM applications or to modernize existing machines and equipment, these versatile, precision-engineered Speed Variators can be used in place of larger variable speed drive units and their connecting electrical drives. If there's room for a motor —an equally sized Cleveland will usually fit in the space.

Here's the complete Motorized Speed Variator story:

- Requires only slightly more space than equally rated standard electric motor
- Provides variable output speeds over 9:1 and 6:1 ranges
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- Integral "pancake" style AC radial air gap motors conforming to NEMA design "B" specification
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Variator is a true torque converter—provides high torque at low speeds for constant HP applications.

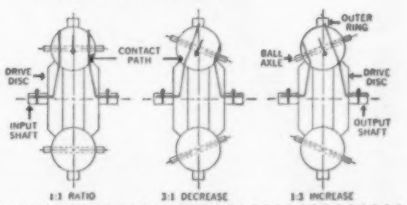
Utilizing the component you wish driven, Cleveland will design and build a complete compact pre-aligned and tested Speed Variator drive assembly mounted on a suitable base plate.

New Motorized Variators offer the ultimate in control versatility. They can be engineered for either manual, electrical or pneumatic operation.

For complete engineering information on the New Cleveland Motorized Speed Variator, write for free, illustrated bulletin Number 275 or contact your Cleveland representative today.

How The Speed Variator Works

Power is transmitted through input shaft to a beveled drive disc in contact with axle-mounted alloy steel drive balls. Input shaft rotation causes balls to rotate about their axles. Power is then transmitted from all rotating balls to output shaft by similar ball-disc contact on the output side. Output speed is determined by relative lengths of contact paths on input and output sides of the balls. By tilting both axles and balls, relative lengths of the two contact paths are varied to give increasing or decreasing ratios as shown on sketches.



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"SCOTCHPLY" Reinforced Molding Compound Type 1100 opens up new possibilities in critical design areas. This new epoxy-fiberglass compound combines outstanding uniformity and high strength far in excess of other molding compounds.

This is why Design Engineers at Detroit Arsenal selected "SCOTCHPLY" Type 1100 as a test material for their swimming test rig wheels. This application demands a lightweight, corrosion resistant material to meet stringent strength and durability tests. For example: Bureau of Standards rim test requires 100,000 revolutions for a steel rim; "SCOTCHPLY" Type 1100 rims exceeded this requirement by 4,350,000 revolutions.

The outstanding performance of Type 1100 is due primarily to an exclusive 3M manufacturing process which produces a uniformity of coating previously not obtainable. This results in a uniform flow in the molding process and a precise uniformity of glass-resin distribution in the finished part.

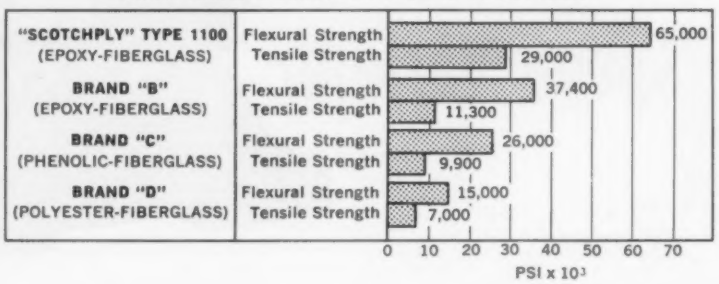
For information on "SCOTCHPLY" Molding Compound Type 1100, write: Reinforced Plastic Division, 3M Co., Dept. XAF-41, 900 Bush Ave., St. Paul 6, Minn.

The "Fox" swimming test rig is presently under development by Ordnance Tank-Automotive Command.

Comparison graph shows that the flexural and tensile strengths of "SCOTCHPLY" Molding Compound Type 1100 top other reinforced molding compounds.

MOLDING COMPOUND COMPARISON GRAPH

(ROOM TEMPERATURE PROPERTIES — ½" GLASS FIBERS)



TEST WHEEL FOR THE "FOX" SWIMMING TEST RIG IS MOLDED FROM "SCOTCHPLY" TYPE 1100 MOLDING COMPOUND.

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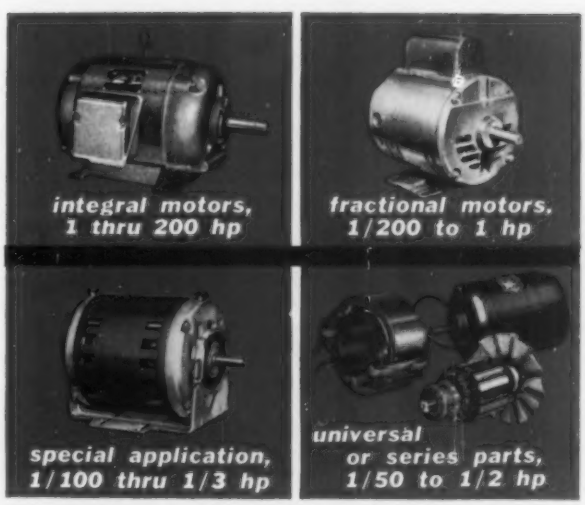
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new ideas
in compact
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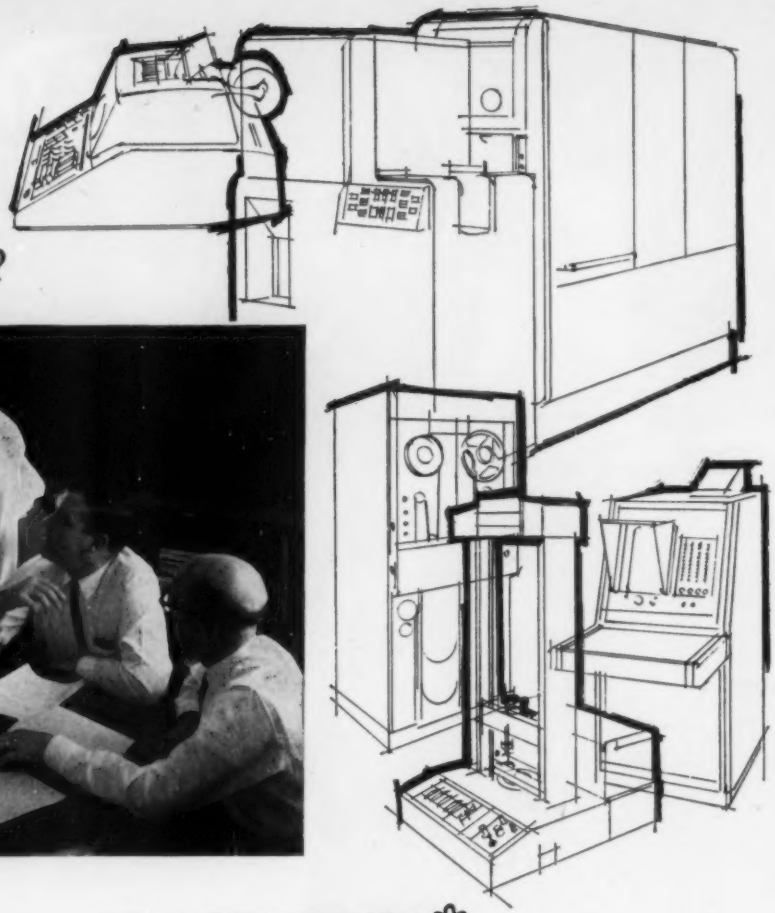

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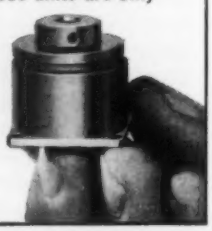
provide high torque per size while controlling complex mechanical movements in limited space. Handling torque loads from 1.5 to 240 lb-in., these units are only 1" to 4" in diameter and just 7/8" to 2-1/2" long. For compact *direct* automatic actuation... investigate these versatile Warner electric brakes and clutches.



WARNER ELECTRIC

Warner Electric Brake & Clutch Co., Beloit, Wisconsin

WARNER ELECTRIC

working with

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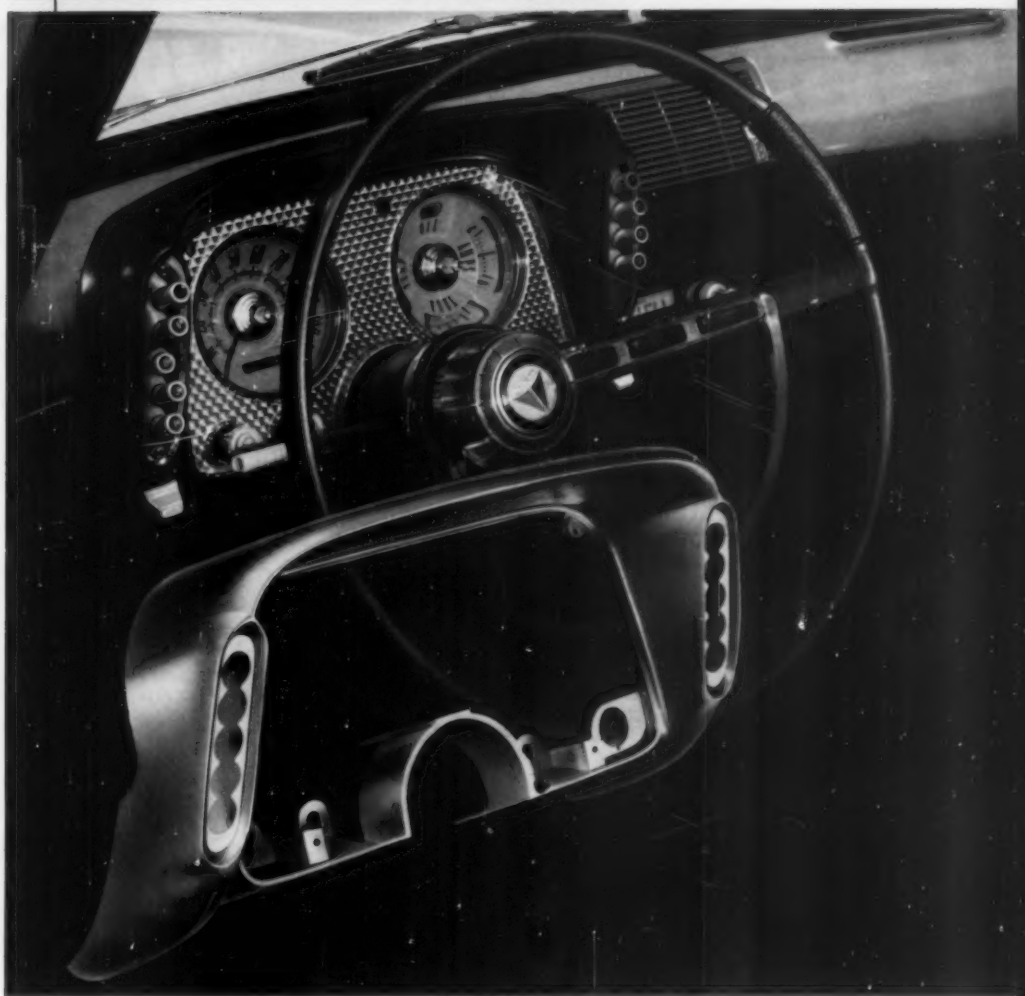

New instrument housing of DELRIN®

cuts weight 80%... simplifies assembly

In designing a compact automobile, weight reduction stands out among the objectives—less weight means improved fuel economy and easier handling. That's one of the reasons why Chrysler Corporation's 1961 Valiant has a one-piece instrument housing molded of Du Pont DELRIN acetal resin. At no sacrifice in performance, the use of DELRIN cuts the weight of the instrument housing by approximately 80%—from nine pounds in die-cast zinc to two pounds in DELRIN. This reduction not only pays off in lower over-all weight, but also eases handling on the assembly line.

The attractively styled housings of DELRIN have proved their durability through extensive road and laboratory tests. DELRIN offers strength in thin sections, even at elevated temperatures . . . remains dimensionally stable under varying conditions of humidity. Mounting of the housing is simplified because molded-in bosses accept self-tapping studs.

On the following page you will find more examples of the product improvements and savings in manufacturing and assembly costs made possible by DELRIN acetal resins in a variety of diverse fields.

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BETTER THINGS FOR BETTER LIVING THROUGH CHEMISTRY

working with

Du Pont Delrin®

one of Du Pont's versatile engineering materials

The manufacturer of these valve components for check valves in water or gasoline pumping systems reports: "Severe testing proves that the disc retainer guide made of DELRIN is practically indestructible." Use of DELRIN instead of brass also prevents mineral build-up . . . eliminates the cause of valve sticking and faulty seating. (Molded by Holman Mfg. Co., for a division of Flomatic Corp., both of Hoosick Falls, N. Y.)

Shock absorber designed to eliminate water-hammer noises in residences has outer shell molded of tough Du Pont DELRIN. Reason for this choice: the shell of DELRIN is highly resistant to damage from residential shock pressures, exterior corrosion from most chemicals and water at 180°F. ("Genie" is molded for Josam Mfg. Company, Michigan, Indiana, by Stelrema Corp. of Gary, Indiana.)

A complete line of miniature oil-tight push buttons (colored buttons, rings and knobs) molded of Du Pont DELRIN to help provide easy identification. Designed for the toughest applications, these push buttons rely on the toughness, color variety, durability and wear resistance of Du Pont DELRIN acetal resin. (Manufactured by General Purpose Control Department of General Electric Co., Bloomington, Illinois.)

Parts of DELRIN® offer rugged, dependable performance under tough conditions

The strength, durability and dimensional stability of DELRIN acetal resin are particularly important when the part in question is subject to severe environmental conditions, such as high temperatures, moisture, solvent and many corrosive chemicals. In use after use, designers are continuing to find that DELRIN provides parts that will perform under these adverse conditions . . . plus substantial economies in manufacture and assembly. How about DELRIN for *your* product? Mail the coupon for further information.

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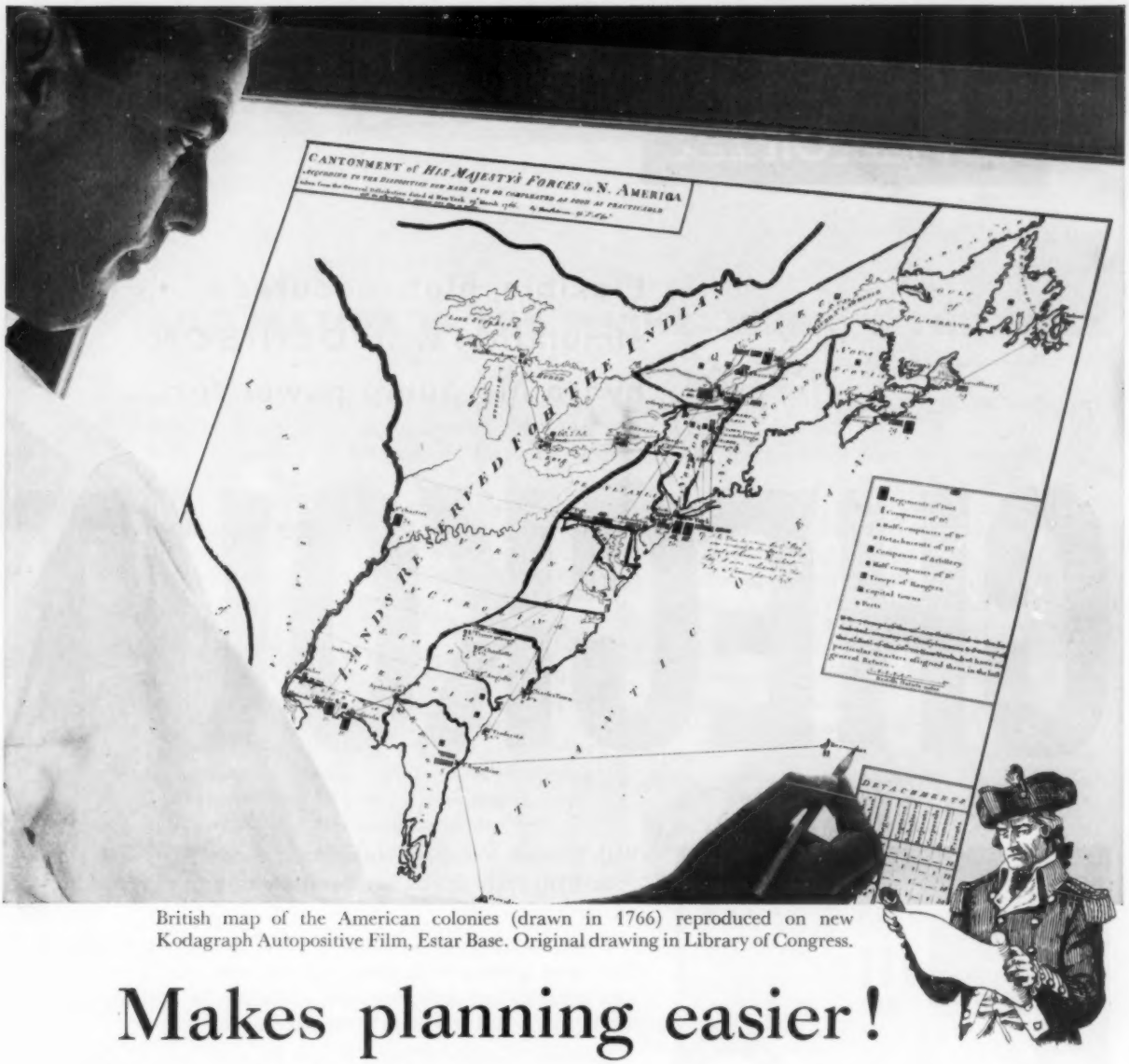
one of Du Pont's versatile engineering materials

Alathon® · Zytel® · Lucite®



British map of the American colonies (drawn in 1766) reproduced on new Kodagraph Autopositive Film, Estar Base. Original drawing in Library of Congress.

Makes planning easier!

New Kodagraph Autopositive Film, Estar Base, produces durable phototracings which have a superior drafting surface on both sides.

Now your print room or local blueprinter can give you second originals that are tough, good looking, and a *pleasure to work with.* Any draftsman or engineer—anyone who takes pencil in hand—will see how much easier it is to draw on either side of these new photo reproductions.

Superior matte surface grips even light pencil strokes . . . lets you use pencils with a wider range of hardnesses. And there's less abrasive action—pencil points stay sharper longer. Also, detail stays put . . . is less inclined to smear, can be erased easily.

All of which makes your job a lot easier.

Easier to process. Direct-positive prints are made in room light with either "print-through" or reflex printing. Famous wide-latitude Kodak emulsion cuts make-overs. Kodagraph Autopositive Film, Estar Base, like all of the new Estar Base Films, comes in standard sheet sizes and in rolls up to 52 in. wide.

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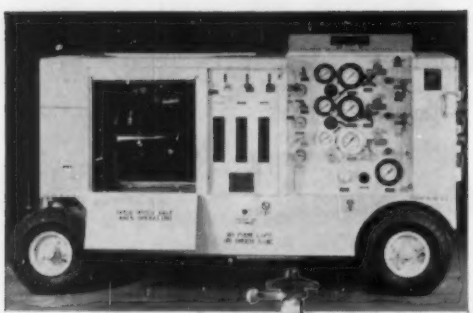

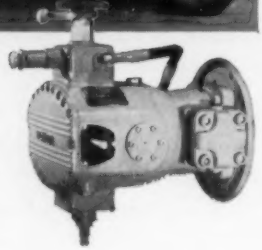

CENTRAL HYDRAULIC PUMPING SYSTEM *used in checkout for aircraft and missiles . . . was designed and built by Sprague Engineering Corp., Los Angeles. It is powered by 3 Denison 22 Series Axial Piston Pumps driven from a common gear case. Prime power can be either an electric motor or a high speed gasoline engine.*

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Denison Variable Volume Piston Pumps – and *all* Denison hydraulic components – are precision manufactured for long, maintenance-free life. Result–you can spend more time checking-out . . . less time checking-up.

Ask your Denison Hydraulics Specialist – located in all principal cities – to show you how Denison hydraulic equipment – pumps, motors, valves, controls – can help you improve the performance of your GSE systems.

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PRODUCT ENGINEERING HORIZONS

April 24, 1961

AUTOMATION IS THE SMOKE—WHERE'S THE FIRE?

One of President Kennedy's first steps was to charge a group of 21 Americans with the task of recommending to him policies that may be followed by labor, management or the public for dealing with such major economic questions as foreign competition and "the benefits and problems created by automation." In the group are seven executives, seven labor leaders, five private citizens, and Secretaries Hodges and Goldberg.

They undertook their task at a time of paradox, when employment was at an all-time high, but unemployment at its highest since 1941. There is increasing evidence that severe dislocations in the labor force are a long-term prospect.

But to reduce the problem to one of prosecuting automation as the culprit is like worrying about the smoke in the midst of an inferno. Foreign competition and automation are just elements in a much greater "benefit and problem"—our accelerating technology. Automation was in 1947 Del Harder's word for the process of applying automatic feeders and extractors to production machines at Ford. It soon was applied to controls as well, then became an omnibus term applied to any mechanization. It has spawned more inexperienced experts, more apostles and viewers-with-alarm, than any recent word in our society.

Actually, only the word is relatively new. The concepts behind it have been motivating equipment designers since the Industrial Revolution. Oliver Evans had an automated gristmill in 1795. Engineers have been working to this goal for years—their success is beginning to show. The present problems have been generated by unrealistic pricing practices by management and excessive wage demands by labor, both inflating product prices far out of line with those of more-conservative countries.

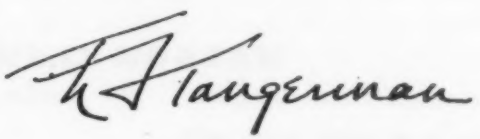
Western Europe is typical. Here are new plants, risen from the rubble of World War II, many more automated than our own. They have taken our European market in many instances, are now challenging us in South America and Asia—and even in our own market. But Europe is *not* suffering from the "problems" of automation—something the committee should study carefully.

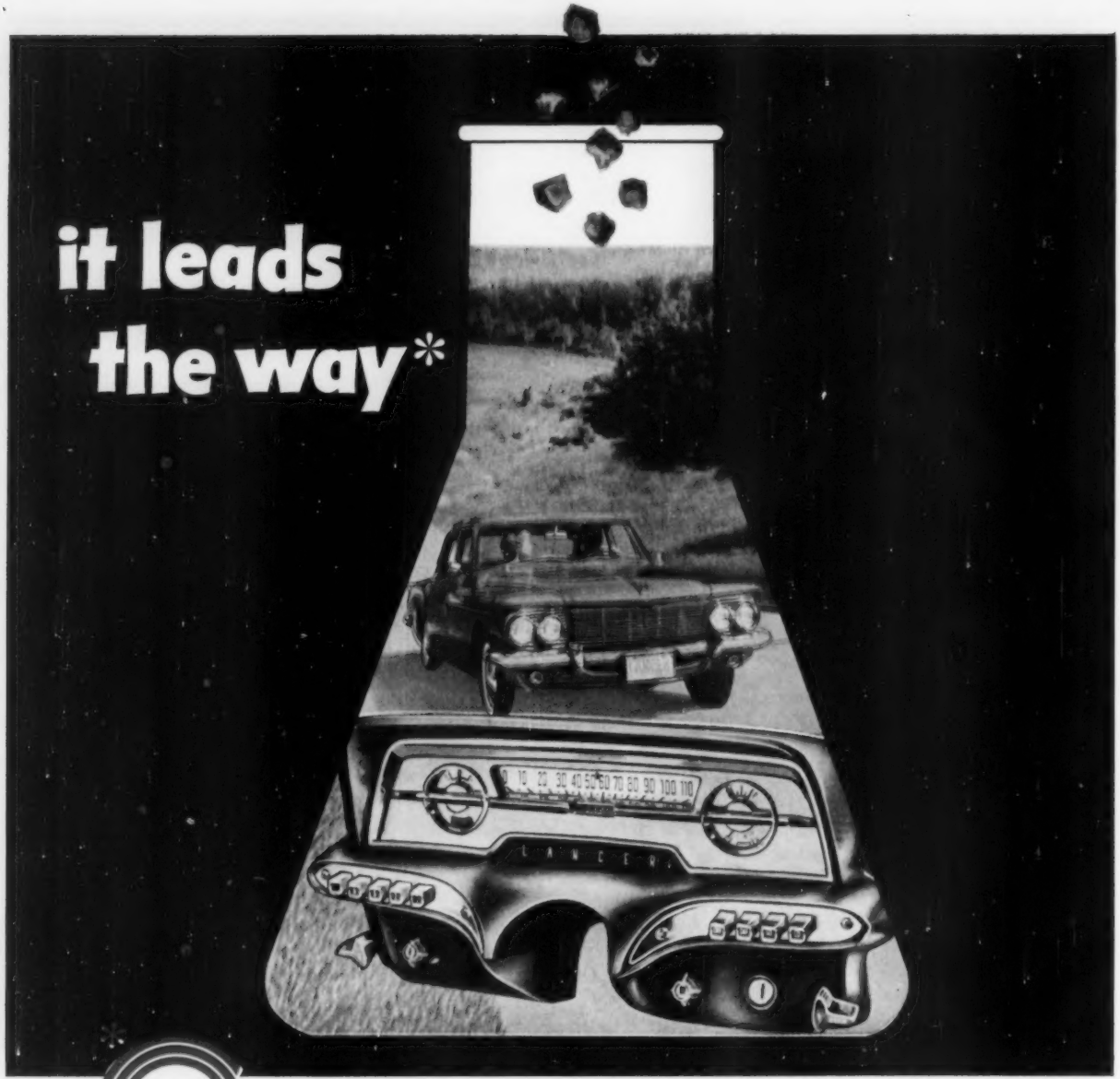
Our own industrial plant is obsolescent—estimates place the cost of modernization at $95-billion. And such modernization would inevitably produce present products faster, with less labor, and offer new products that would make still more equipment obsolete—worn out or not. Secretary Goldberg, in particular, has been pressing for replacement while he points out that: "Automation, for example, upgrades the entire labor force by requiring higher educational and occupational attainments. It sets a bright new premium on skill and intelligence. But are we equipped to handle the educational and training needs inherent in such change?"

Beyond that, Mr Secretary, are we equipped to handle the further dislocation of labor, to reward skill and intelligence rather than seniority and union membership? Are we ready to offer the incentives for capital investment in industry to make automation possible? Are we ready to absorb elsewhere the unintelligent worker and the small business man? Just how many incompetent TV and appliance service men can we stand, how many corner stores, how many door-to-door salesmen?

These are only the beginnings. What of the technological acceleration we mentioned earlier? What of the solid-state unit that knocks out an automated assembly machine for radios or switches, the superjet airplane that knocks out ten propeller planes, the color TV that makes movie palaces into ghost castles, the "one-shot" plastic and cast products that avoid assembly entirely? These go far beyond automation in providing "benefits and problems."

Perhaps, Mr President, we need another committee—one of scientists, engineers and educators to predict the slope of the acceleration curve. Then the present committee can face the war and not one battle, can deal with strategy and not tactics, with our technological society instead of just automation. The first step is to define the problem.





Lancer Instrument Cluster molded by Kent Plastics — Evansville, Ind.

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It's another great one from Dodge . . . the Lancer Compact. And no wonder. Just look at this style-trimmed instrument panel cluster molded of CYCOLAC brand ABS polymers. Pounds lighter than metal, it's strong and tough, will never rust, stain or tarnish. Warm and smooth to the touch, molded parts of this ABS material remain new-looking for the life of the car. Economical, too . . . a cluster can easily be produced in intricate shapes and vacuum metalized without difficulty. Installation is fast, simple. No marring or scarring; little post-installation finishing required. And CYCOLAC brand polymers are colorable too . . . to exactly match-meet the myriad of automotive finishes. Proof again that this Borg-Warner material is the most versatile of all plastics. Investigate . . . for full details write Dept. 3-C.

MARBON CHEMICAL DIVISION **BORG-WARNER**

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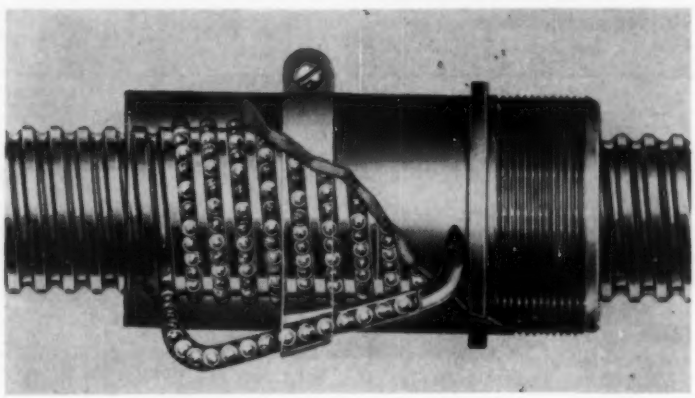
PRODUCT ENGINEERING

how to design with PRECISION BALL SCREWS



1. CONTINUOUS RECIRCULATING BALLS, rolling in helical grooves, provide ability to carry heavy loads with low friction and high efficiency.

As converters of rotary to linear motion, they are replacing the acme power screw in many applications. Here are their load and speed characteristics, methods for preventing reversibility and over-travel, and a simplified 10-step design procedure.

JOHN A HOPE, *vice-president*
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Ball screws are efficient converters of rotary-to-linear or linear-to-rotary motion. Their function is similar to that of the acme screw and nut, but with these important advantages:

- High conversion efficiency—Ball screws permit linear actuation of heavy loads by means of a small power source.
- Low starting friction—This is another factor that keeps input power requirements low.
- Accurate positioning—With proper preloading, ball screws permit accurate positioning of machine components, with little wear and almost zero backlash.

Precision ball screws, with total cumulative error in the lead as low as 0.0001 in./ft, are finding wide usefulness in machine tools, testing and transfer machines, automobiles, farm equipment, aircraft and missiles.

How a ball screw operates

A typical ball-screw assembly, Fig 1, consists of two components: a screw with circular-form threads, and a nut assembly with an internal helical ball groove to permit the flow of a continuous row of steel balls. Rotation of either the screw or nut causes the rolling balls to move along the helical path. The balls travel at approximately half the speed of the races and exit at the trailing end of the nut. To keep the balls rolling continuously in the system, a return tube deflects and recirculates the balls to the leading end of the nut.

Basic operation of a ball screw is illustrated in Fig 2:

- (A) Rotary motion applied to the screw (manually or by a power source) drives the nut linearly along the screw axis.

continued, next page

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I—DIMENSIONS AND RATINGS OF BALL SCREWS

Nominal Screw Dia, in.	Rated Operating Load, lb	Max Static Load, lb	Threads Per in.	Ball Dia, Balls	BALL NUT DATA: Turns of Balls	Min O.D. in.	Min Length, in.	Torque at Rated Load, lb-in.
5/16	700	3,800	10	1/16	7 1/2	0.48	0.95	12
3/8	900	5,000	10	1/16	7 1/2	0.54	0.95	15
7/16	1,300	7,000	8	5/64	8 1/2	0.64	1.31	29
1/2	1,800	10,000	8	5/64	8 1/2	0.70	1.31	40
5/8	2,600	14,000	7	3/32	8 1/2	0.87	1.50	66
3/4	3,300	18,000	6	7/64	8 1/2	1.03	1.75	98
7/8	4,500	25,000	5	1/8	9 1/2	1.20	2.30	159
1	5,500	30,000	5	1/8	9 1/2	1.33	2.30	195
1 1/4	8,600	47,000	4	5/32	9 1/2	1.62	2.88	380
1 1/2	11,000	60,000	3 1/2	3/16	10 1/2	1.99	3.57	556
2	18,000	100,000	3	7/32	10 1/2	2.57	4.16	1,060
3	36,000	200,000	2 1/2	9/32	10 1/2	3.73	5.00	2.550
4	59,000	320,000	1 3/4	3/8	10 1/2	4.98	7.13	5,980
5	100,000	550,000	1 1/2	1/2	10 1/2	6.30	8.35	11,800
6	160,000	825,000	1	5/8	10 1/2	7.63	12.37	28,300

II—CONVERSION TABLE: LOAD VS LIFE

Rated Load, %	Life, million inches travel
10	1000.0
25	64.0
50	8.0
75	2.4
100 (Rating)	1.0
125	0.512
150	0.296
175	0.186
200	0.125

• (B) Rotary motion applied to the nut (manually or by a transmission drive such as gears) drives the screw linearly.

Because of the low coefficient of friction, both rotary-to-linear functions are reversible; that is, a linear motion of either the screw or nut can cause the other member to rotate.

Threads on most types are machined or rolled. When machined, they are rough cut, hardened and then ground to obtain highest positioning accuracy, efficiency, load capacity and life. Rolled threads, on the other hand, are cheaper to produce and offer considerable cost savings if quantities are sufficiently high.

BALL-SCREW CHARACTERISTICS

Load-life characteristics of ball screws are similar to those of ball bearings. Because most of the loading is in thrust, ball screws operate similarly to a series of angular-contact ball bearings. The sides of the ball grooves extend almost to the midpoint of the ball.

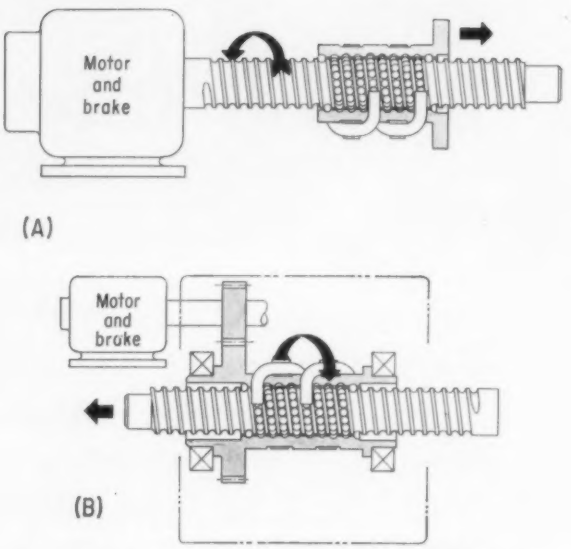
Static loading

A ball can carry a much greater load in a closely conforming raceway than on a flat surface. In fact, when the radius of the raceway or groove is only slightly larger than that of the ball, the load-carrying ability is over three times greater than that of a ball rolling on a flat plate. In ball screws, conformity of raceway to balls is closer than generally realized—groove radii of 51 to 52% of the ball diameter are normal. (Closer conformity will result in too much scrubbing action during rolling.)

Static load-carrying ability of a ball on a surface varies with the fourth power of the Brinell hardness number of that surface. This explains why raceways with a Rc 63 hardness are desired for ball bearings. Ball screws and nuts are made to Rc 60—but this value is sometimes reduced because of high structural-strength requirements.

Dynamic loading

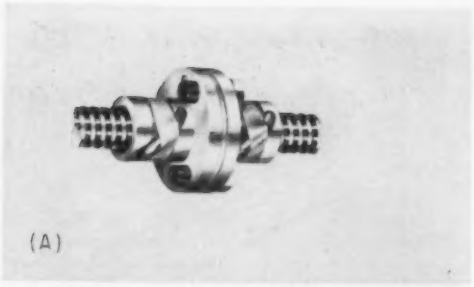
The dynamic load-carrying capacity (or rated operating load, Table I) is usually of greater importance than the

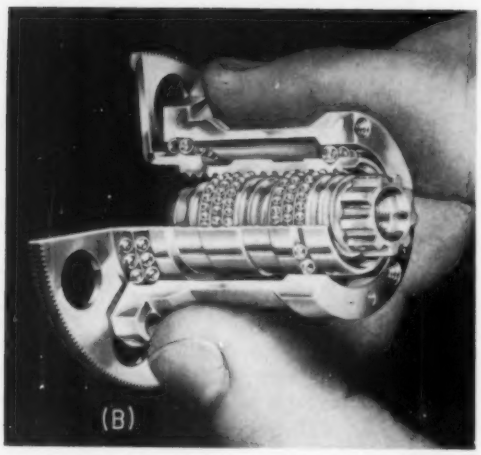


2. BASIC OPERATIONS: Rotary motion to (A) screw, or (B) nut, causes other member to travel linearly or provide linear force.

static load capacity. Since fatigue is the primary cause of failure, the load-life rating of a ball screw is based on the number of times a ball rolls over a particular point in the raceway, and the load on that point as each ball passes over it. Life varies inversely as the cube of the load; cycles to failure decreases rapidly as the load per ball increases.

Ball screws are rated at 1 million inches of travel, Table II. Doubling the rated load cuts life to one-eighth (125,000 in.); reducing the load in half increases life eight times (to 8,000,000 in.). About 90% of any large group of identical units may be expected to be equal to or exceed the rating. This rated value is only about one-fifth the actual average life. Thus if a ball screw is running smoothly at





3. TO REDUCE AXIAL PLAY, ball screws are preloaded by double-nut system (A) or double circulating system (B).

the time it reaches its rated life, it will probably continue operation again as long as a new unit.

Groove hardness

Raceway hardness has a critical effect on the dynamic life of ball screws. Reducing the recommended hardness from Rc 60 to Rc 50 cuts the expected load capacity in half. A further reduction to Rc 45 lowers life approximately 30%.

Race hardness does not affect the spring rate, but races with greater hardness are able to withstand more deflection safely.

Efficiency

Ball screws have efficiencies consistently in excess of 90%. Best techniques for determining ball screw efficiencies involve measuring only the losses due to friction. Methods based on measurement of total output thrust and the total input torque often give confusing results because errors of determination can easily be greater than the losses in an efficient ball screw. With ball screws of conventional proportions, the efficiencies in converting torque to thrust and thrust to torque are not significantly different.

End play and preload

Ball screws possess a certain amount of inherent axial freedom or end play. In this respect, the ball screw is similar to a deep-groove, single-row ball bearing. If both nut and screw grooves have the same radius, the axial freedom is a function of four times the difference between the groove and ball radii. Axial freedom also varies with the angle at which the ball contacts the groove. The contact angle is measured between the normal to the screw axis and a line through the ball center at 90° to the rolling axis of the ball. For typical ball screws with a radius 52% of the ball diameter and with the balls making contact at 45° angle, axial play equals 5.6% of the ball diameter.

Decreasing the groove radius reduces the end play. Also, if a groove is ground several ten-thousands of an inch shallower, it has a reduced contact angle and, as a result, less axial freedom. However, a shallower groove increases the ball pressure and reduces life (for a given external load) faster than the axial freedom is decreased.

Ogival (or gothic-arch) groove forms are often requested in ball screws to reduce axial freedom without greatly increasing the ball pressure. Variations in groove depth do not change the contact angle as rapidly as with a round groove. However, the ogival form reduces ball conformity and its load-carrying ability.

Axial play can be avoided by preloading. The ball screw in Fig 3(A) uses a double nut for this purpose. The method is similar to that used for face-to-face or back-to-back angular-contact ball bearings. There is little sacrifice of efficiency at full load because the preload is alleviated as the external load builds up. Axial play can also be removed by a method analogous to that used in double-row ball bearings, Fig 3(B)—but at a sacrifice in ease of adjustment.

Numerically controlled production machines frequently utilize the double-nut type, shown in (A), for high system stiffness. Positioning accuracy directly from the tape has been held to 0.000,15 in., and repeatability accuracy to 0.000,050 in.

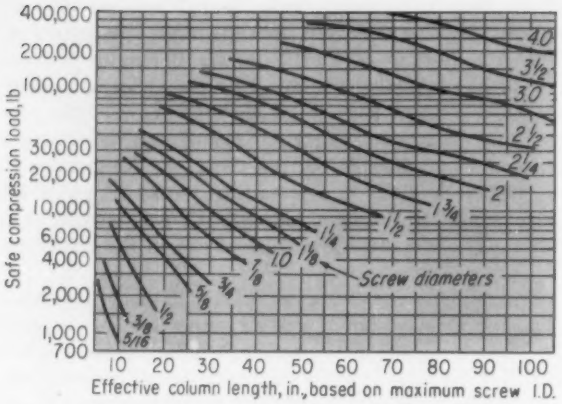
DESIGN CONSIDERATIONS

Axial load

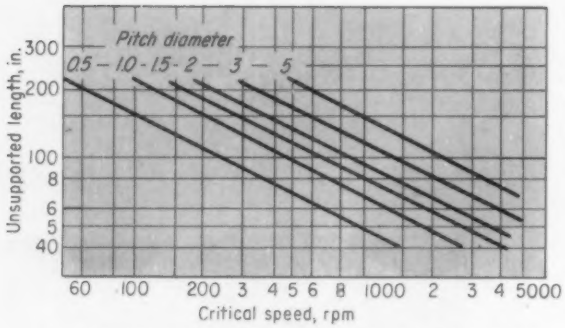
Axial load-attachment points on the nut, such as a flange or V-thread, should be located with reference to the load-attachment points on the screw (on the end of the nut away from the load end of the screw) so that there are like stress signs (tension or compression) in the screw and nut body. Avoid thin-walled nuts with trunnions at the midpoints for two reasons. Trunnion deflection forces the trunnion base on the compression side to move inward and causes highly localized ball loading. Also, on one end of the nut, the stress sign for carrying the load will be opposite to that in the screw.

Overturning and side loads

Wherever possible, the load direction in ball screws should coincide with the axis. This avoids overturning or side loads. An overturning loading increases the total load on the balls in the end turns of the nut; side loads increase the stresses on a limited number of balls and a limited portion of the groove. If present, side loading or overturning moments must be allowed for in the same manner as the combination of axial and radial loads in ball-bearing applications. Normally, it is easier to avoid



4. COLUMN LOAD CAPACITIES for hollow shafts of various diameters and lengths.



5. LOWEST CRITICAL SPEEDS (first order) for solid shafts of ball screws with simply supported ends.

side loads in design than it is to make the ball screw large enough to withstand them.

Column loading

Ball screws are frequently employed as pin-ended columns. The curves in Fig 4 give safe compression loads for simply supported hollow screws of various lengths and diameters. These are minimum values because varying degrees of end fixity will increase the load capacities considerably. The left end of each curve approaches the maximum static load for the corresponding size; the right end stops at a point where column length divided by the radius of gyration equals 150.

Critical speeds

Every shaft has several natural frequencies at which it will vibrate severely. Resonant frequencies will also occur when the screw is fixed and the nut rotated, if the relative rotational speed of the nut is equivalent to the natural frequency of the screw. It is best to stay at least 20% below the lowest critical speed in ball screws.

Critical speed is a function of the end mounting (ends can be clamped, merely supported or entirely free), length and screw diameter. Of all the variables, the unsupported length has most effect because the critical speed is inversely proportional to the square of the length. A shaft 100 in. long will have a critical speed of one-fourth that of a shaft 50 in. long. Critical speed is directly proportional to the diameter—doubling the diameter doubles the critical speed.

Resonance problems can be avoided by increasing the screw lead to lower the rotating speed, or by employing hollow screws to increase the critical speed. For difficult problems, retractable fingers can be provided to support the midpoint or several points along the screw length.

The curves in Fig 5 show the lowest, or first order, critical speeds for solid shafts with simply supported ends (such as radial or angular-contact bearings). If the shaft can be clamped at one end, multiply the rpm by 1.6. If it can be rigidly held at both ends, multiply the rpm by 2.3.

Axial deflections

In addition to the axial deflections within ball screw components under load, there is also a very substantial amount in the anti-friction bearings.

It is inadvisable to fasten the wheel of a worm-gear set directly on a ball screw or nut unless the thrust bearings are preloaded. Otherwise, deflection of the ball bearings under ball-screw loads will allow the worm set to move out of alignment, with resulting loss in efficiency and life of the gear set.

Ball-screw enclosure

It is best to completely enclose ball screws to exclude dirt. This also preserves the lubricant. Telescoping shields with dirt-tight glands give good protection, and bellows-type enclosures serve well where the screw requires protection from dirt only.

Where complete enclosure is impossible, use wiper seals on the ball nuts to prevent entrance of metal chips and all but the finest dirt. Where the screw rotates, the nut can be sealed within an extension tube connected between the ball nut and the load—but this requires a longer over-all assembly length than that of the trunnion type.

Preventing reversibility

Because these devices are highly efficient in converting thrust to torque, a heavy thrust load can cause the screw to reverse. Some designs rely solely on the losses in high ratio gear trains to prevent reversal, but frequently more positive means are necessary.

Spring-loaded, electrically released brakes are sometimes used with electric drives, or with a hydraulically released counterpart where hydraulic motors provide the drive.

Spragging locks, Fig 6(A) with a means of unlocking from the driving side, can prevent runback, but have a tendency to chatter when the load attempts to run ahead of the drive. These devices do depend on rotation to develop braking torque, therefore they require some method of releasing the spragging member when the drive torque is reapplied.

Load-sensitive "no-back" devices, Fig 6(B) used directly on the screw are very effective.

When power is applied through the gear to drive the load to the right, the overrunning clutch or ratchet turns

10 STEPS—DESIGNING WITH BALL SCREWS

Step 1: Prepare a geometry of the linkages. This establishes the stroke and, with related data, linear speed.

Step 2: Determine the loading on the ball screw. Column action may occur if the loading is in compression on the link which becomes the linear actuator. If the column is short, skip to **Step 4.**

Step 3: Determine the necessary screw diameter from Fig 4 to avoid column action. For solid steel shafts use the formula:

$$\frac{P}{A} = \frac{286 \times 10^6}{(L/\rho)^2}$$

where: P = column load, lb
A = cross-sectional area, sq in.
L = length of column (pin to pin), in.
ρ = Radius of gyration of cross-section, in.

In determining A and ρ, the average between actual OD and root gives the equivalent OD of the screw. Where the screw is only part of the actuating link, and an extension tube from nut to pin at the other end comprises half or more, the average area and radius of gyration for the full length can be determined by the following approximation:

$$\rho = \frac{L_1\rho_1 + L_2\rho_2 + \cdots}{L}$$

and

$$A = \frac{L_1A_1 + L_2A_2 + \cdots}{L}$$

Step 4: Find the peak static load that can be imposed on the screw link. This value is the "maximum static load" column of Table I (p 60). It also establishes size of the screw if column loading does not exist.

Step 5: Find the permissible average operating load from the second column of Table I. These figures are based on a life of 10^6 in. of ball-screw travel. By knowing length of the full stroke you can determine min life of the system in terms of operating cycles (one cycle equals twice the stroke).

A jacking load (raising and lowering) will give half the life of a friction load (pushing and pulling). With a friction load the ball load moves from one side of the groove to the other as the direction of the nut reverses; with a jacking load, the ball load is always on same side of the groove.

Step 6: From the table, find the lead of the thread—threads per in. ("tpi").

Step 7: With this value, compute rpm of the screw. Rpm equals linear speed, in./min., divided by the lead, in inches. Lead is the reciprocal of tpi; for example, 5 tpi equals 0.2-in. lead. This establishes gear-reduction ratio between the motor (or crank) drive and ball screw. The lead can be varied to suit an existing gear drive, although generally it is more economical to vary the gearing.

Step 8: Compute the required torque input. This is a function of the lead. Thus:

$$T = \frac{P\,l}{2\pi e}$$

where: P = load or force, lb
l = lead of thread, in.
e = screw efficiency (more than 90% with normal loads)

If the computed value is too high, another screw size, or one with a special lead, may be required.

Step 9: Check critical speed of the rotating screw from Fig. 5. This should be done even if the nut is rotating and the screw translating.

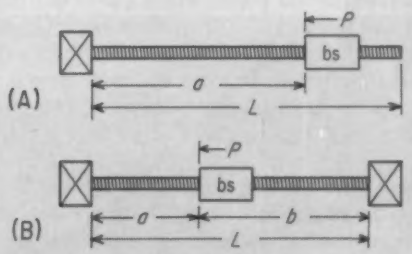
Step 10: Check the system stiffness. In numerically controlled machines or missile controls, the system stiffness (in axial direction) requirements may determine the screw diameter. Stiffness is best given in terms of spring rate (linear deflection or elongation of the bar per unit load). If the load is constant, deflection (min stiffness) occurs at midpoint of the stroke when the screw is stretched slightly between thrust bearings. If the screw is supported at one end only as shown in sketch (A), the spring rate of the screw is:

$$K_s = \frac{A\,E}{a}$$

For screws with angular-contact bearings at both ends, sketch (B):

$$K_s = \frac{A\,E\,L}{ab}$$

where a, b, = dimensions (see sketches), in.
A = cross-sectional area, in.^{2}
E = Young's modulus (30×10^6), lb/in.^{2}
P = applied axial load, lb
K_s = spring rate of screw, lb/in.

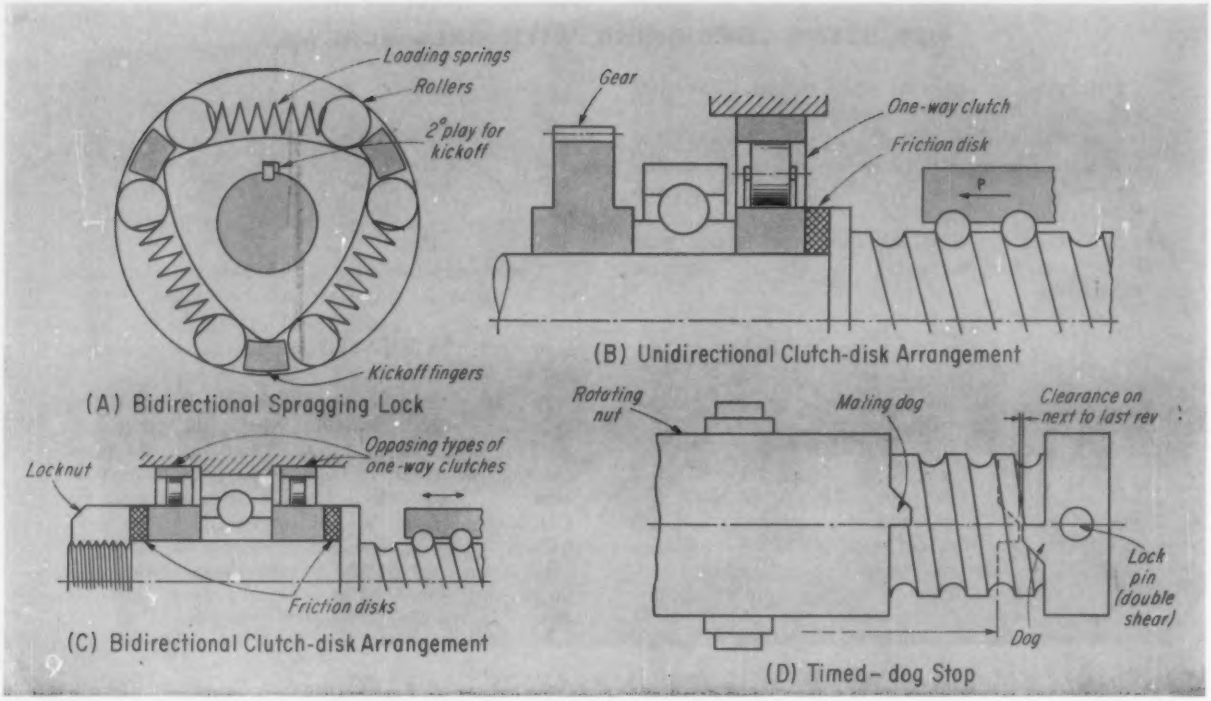


Stiffness is also influenced by deflection of the balls in the ball screw. For a rough estimate, spring rates of preloaded ball nuts can vary from 10^7 up to 50^7 lb/in. In some cases, rates of 100^7 have been obtained in very large dia screws with numerous large-dia balls.

Stiffer systems will be attained with larger quantities of balls because the deflection of balls is directly proportional to the $\frac{2}{3}$ power of the load and inversely proportional to the $\frac{1}{3}$ power of the ball diameter.

freely. When the power is released, the load trying to reverse the screw acts through the friction disk and attempts to turn the overrunning clutch in its locking direction, and the load is held. When the power is applied to drive the load to the left, it overcomes the braking action of the friction disk—even though the overrunning clutch remains locked.

In Fig 6(C) is shown a bidirectional arrangement. When the load is applied to the left, the friction disk and overrunning clutch arrangement on the left is effectively



6. NO-BACK DEVICES prevent reversal under load.

out of the system. The reverse is true when the load is applied to the right. Such devices are limited by their ability to dissipate heat. The bidirectional arrangement is used for wing-flap actuators of aircraft.

Servo devices also prevent reversibility. One type employs interleaved friction plates, which are locked together by the load and released by the drive motor. A modification of this device has a spring to lock the plates together against backward rotation. Its system of bidirectional ramps permits the drive mechanism to relieve spring pressure and drive the screw against the load or hold it with the load.

All of these servo devices require the first increment of drive motion to effect the release. They do not have to dissipate any substantial amount of motor power and have greater thermal storage than the load-sensitive types. On the other hand, the servo devices are generally more complicated in design.

Travel-limiting devices

Travel of the nut should be limited, if for no other reason than to prevent accidental disassembly. When travel stops must withstand very high impact loads, resilient materials, such as nylon or rubber, or springs, can be employed. Helical springs or Belleville-spring packs sometimes flatten under the impact loads, creating a nonreleasing condition. Ring springs are better—they dissipate much more energy than other spring devices within the same space, and still release properly.

"Timed-dog" stops, Fig 6(D), often used by designers, operate by missing each other one revolution (before impact), and then making contact entirely in torsion one revolution later. Torsional resilience absorbs the impact, and the stored energy helps release the ball screw for return travel.

Materials

Most ball screws are either carburized, or surface-hardened by induction or flame heating.

The heat-treatable and precipitation-hardening stainless steels are now finding widespread application in corrosive environments. All-aluminum units are becoming popular in servo systems where a low mass moment of inertia is desirable and where loads are light.

Lubrication

Oil is best lubricant for ball screws, but a good grade of light grease is frequently satisfactory. In either case, only enough lubricant should be applied to maintain a continuous film to assure long life at the rated load. Avoid greases containing graphite because an excess builds up and eliminates internal clearances in the unit.

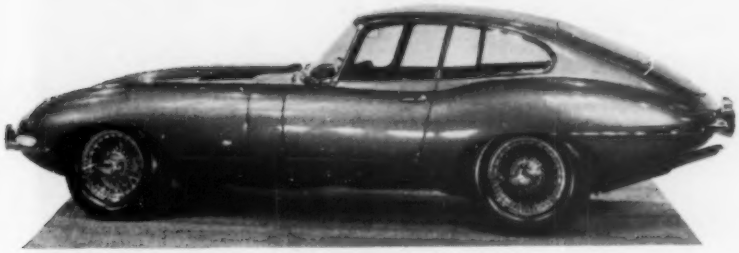
For REPRINT of above article, just check 601 on one of the Reader Service cards found in this issue.

EDITOR'S NOTE: For other ball-bearing linear devices see:

Your Guide to Ball Bearing Slides, June 27 '60, p 34—Rundown on basic types of linear slides, load capacities and best mounting methods.

For the complete text of eight earlier articles presenting design considerations in the selection and application of ball and roller bearings, order a copy of the new 64-page combined reprint "Rolling Element Bearings" from Reader Service Dept, Product Engineering, 330 W 42nd St, NY 36. Price $2.

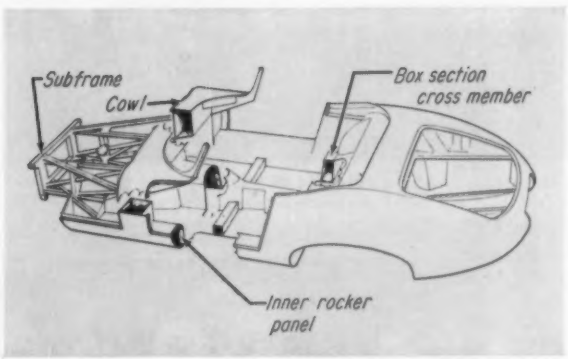
—Nicholas Chironis

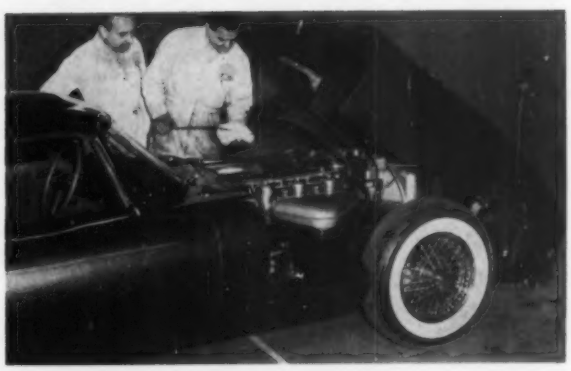


Jaguar's XK-E:

Solid, Lightweight, Easily Assembled

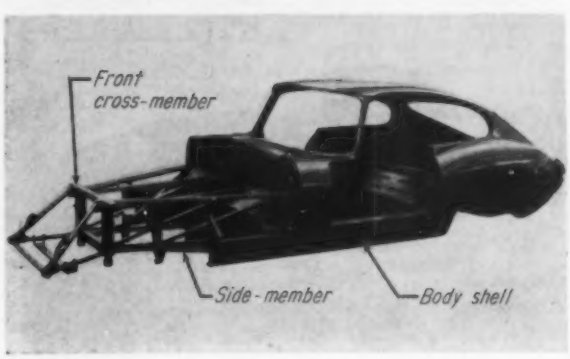
It's been adapted from a successful competition sports car for volume production and everyday use. Stressed-steel skin for main shell adds rigidity and saves weight, steel-tube subframe speeds construction and repair; double-duty half-shaft simplifies independent rear suspension.

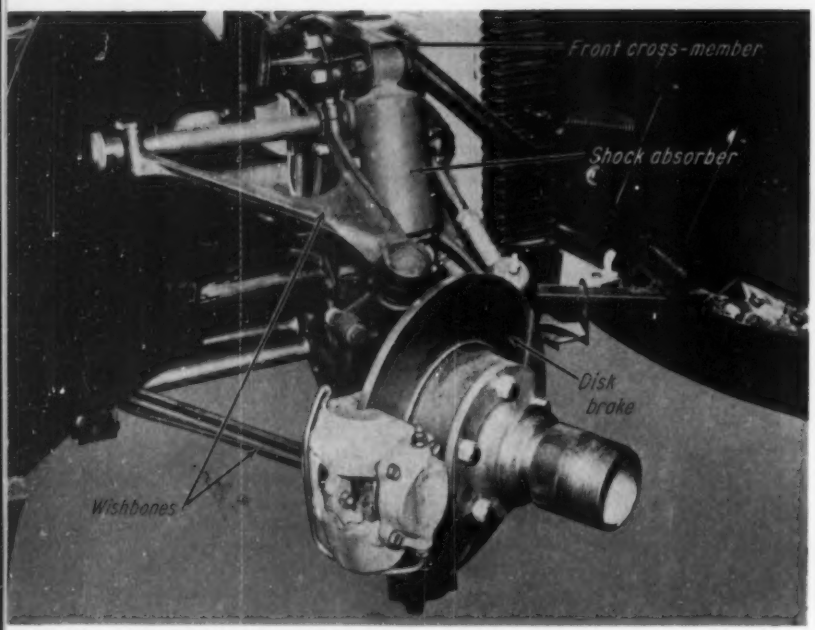




BODY SHELL, formed from a stressed skin structure, is fabricated of 20-gage steel sheet. Deep curves used in the body shape provide a significant contribution to structural stiffness. Basic structure of the body consists of two large-dia longitudinal members which run the length of the body shell. They are constructed from the outer skin panel and inner rocker panel. At front, two large vertical box-sections are welded onto top of the longitudinal members, and these are built into a very deep box-section cross-member which forms cowl of the body. At rear, a deep box-section cross-member is continued upwards to form a diaphragm between the rear wheel wells, and the panel across the top of the wheel wells is also boxed for additional stiffness. Rear section of body is built up as a stressed-skin unit, with heavy-gage stiffeners which come up from the rear cross-member and form the base to which the rear suspension and drive units are mounted.

The forward subframe is constructed from square-section steel tube and bolted to front of the body shell. To simplify manufacture and replacement, subframe is built up from two triangulated side-members plus a deep front cross-member. These pieces are bolted together and may be replaced individually. Subframe carries the engine and all its accessories, plus the front suspension and steering gear. Since subframe carries the entire load forward of the body shell, the front section consisting of hood and fenders is unstressed. The entire section is hinged to tilt forward, providing excellent access to the engine and suspension.



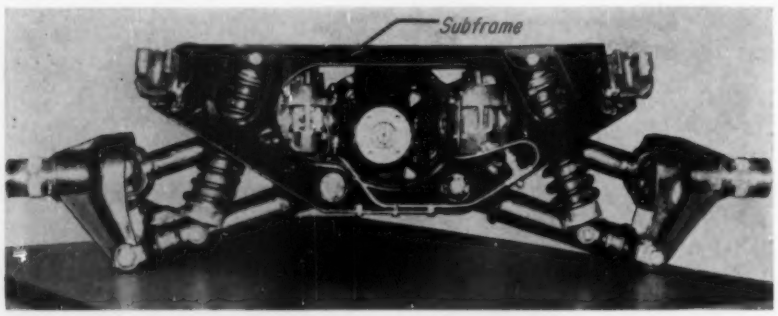


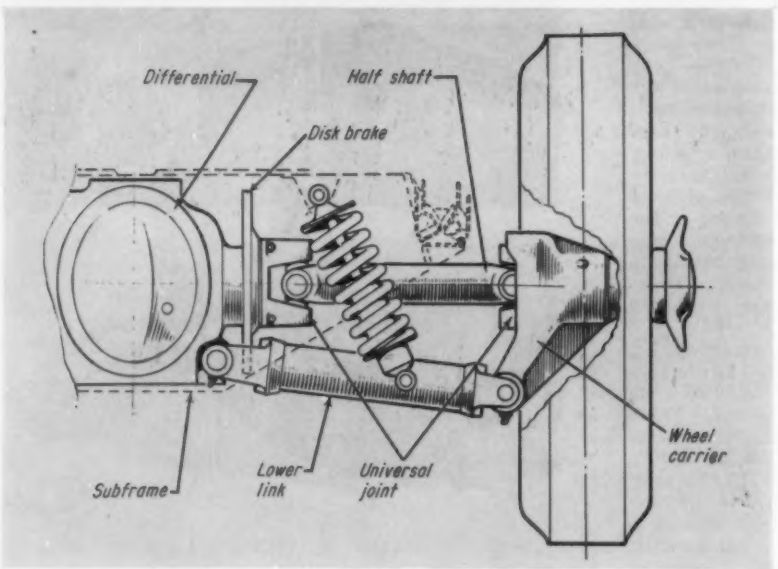
JAGUAR XK-E

Wheelbase	96 in.
Track, front and rear	50 in.
Over-all length	175⅜ in.
width	65¼ in.
height	48⅛ in.
Ground clearance, loaded	5½ in.
Turning circle	37 ft
Weight of Roadster	2464 lb
Coupe	2520 lb
Weight distribution, front/rear	50%/50%
Tires	6.40 x 15

Engine

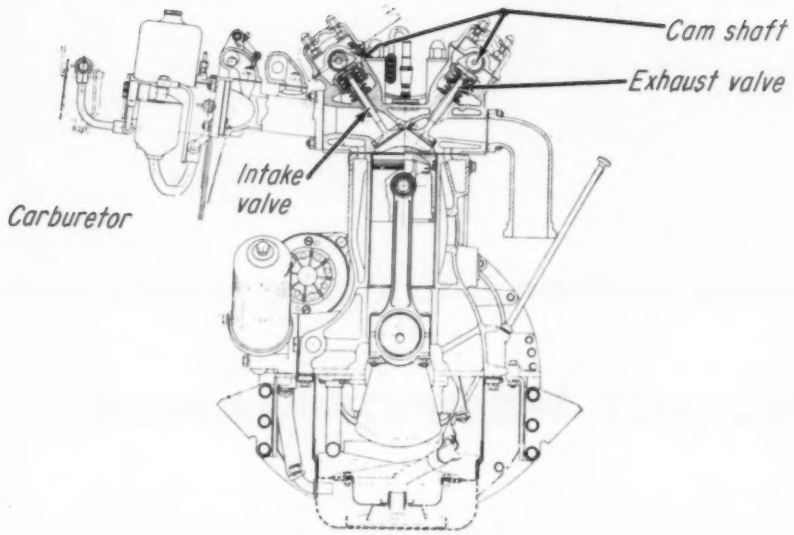
No. of cylinders	6
Bore	3.425 in.
Stroke	4.1732 in.
Displacement	230.64 cu in.
Compression ratio	8:1 or 9:1
Horsepower	265 bhp @ 5500 rpm
Torque	260 lb-ft @ 4000 rpm





INDEPENDENT SUSPENSION on all four wheels provides excellent road-holding ability. Front suspension uses transverse wishbones and torsion bars. Torsion-bar front ends are mounted in extensions of the lower wishbones, making it possible to remove and replace the bars without disturbing the rest of the suspension. Ball joints on the wishbones provide articulation required of the stub axle for wheel bounce and steering. Hydraulic shock absorbers are used for damping, and a sway bar is fitted to the lower wishbones.

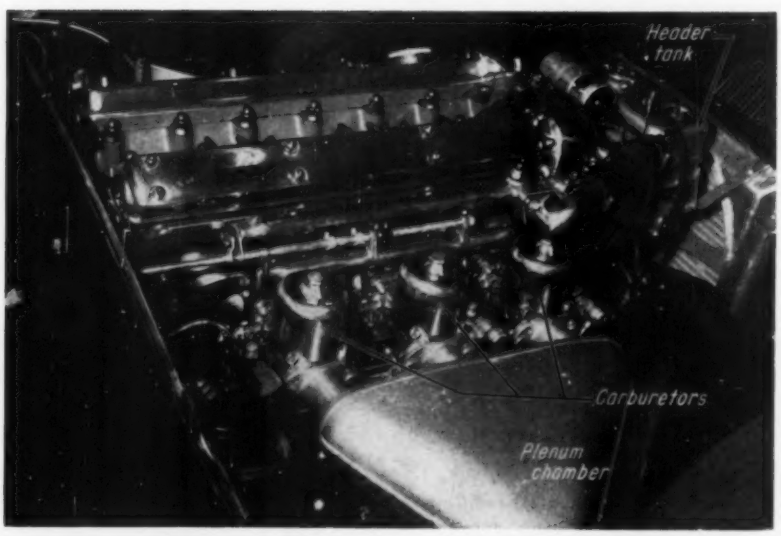
The rear suspension is mounted in a detachable steel subframe. This is connected to the body shell by rubber blocks and a radius-rod running between the lower suspension link and the body. The radius-rods have rubber bushings, and the entire suspension is permitted to move slightly. This insulates the assembly, eliminating the noise and vibration usually produced by independent suspension systems. Location of the wheels in a transverse plane is achieved by two tubular links. The top link is the half shaft, which also drives the rear wheels. Lower link is pivoted at the forged-aluminum wheel-carrier and at the subframe adjacent to the differential casing. For maximum rigidity in the longitudinal plane, the pivot bearings at both ends of the lower link are widely spaced. Twin coil springs enclosing tubular shock absorbers are mounted between the lower link and the subframe. The disk brakes are mounted inboard to reduce unsprung weight.



ENGINE has a cast iron block with dry cylinder liners and an aluminum-alloy head. Twin camshafts in the head operate the valves directly through inverted tappets. Three carburetors supply the 6 cylinders through short intake pipes that provide uninterrupted path to the valve. Fuel is supplied by a submerged fuel pump located in the fuel tank. Air to the carburetors is supplied from a plenum chamber atop the air cleaner. The crankshaft runs in 7 lead-indium bearings and is statically and dynamically balanced. Steel connecting rods are drilled to lubricate the wrist pins and their bearings.

The pressurized cooling system uses an electrically driven fan rather than the conventional engine-driven unit. This ensures a high rate of airflow at low speeds and permits coolant temperature to be closely controlled. A thermostatic fan control switch in the header tank, mounted between the engine and radiator, switches the fan in at 175 F and turns it off at 160 F. Radiator is cross-flow type, constructed of aluminum and mounted on the front subframe.

The servo-assisted brake system has separate master cylinders for the front and rear brake systems which work independently. A whiffletree connection between the master cylinders permits adjustment of the force applied to front and rear units. A third master cylinder actuates the hydraulically operated clutch. Hydraulic reservoirs maintain an adequate supply of fluid for all master cylinders.



PS . . . Capable of speeds to 150 mph, the coupe and convertible have been developed from a successful competition sports car in production since 1954. These "grand touring" cars are designed for traveling long distances at high speeds with safety and comfort. A 6-cyl engine, with 3 carburetors and twin overhead camshafts produces 265 bhp to provide high performance. Four wheel disk brakes with servo assistance provide the stopping ability required for safety. For added comfort, car has adjustable bucket seats and a steering wheel with adjustments for height and reach. The XK-E Coupe and Convertible were introduced at the NY International Automobile Show, April 1-9, by Jaguar Cars Ltd, Coventry, England.

Your own experience written into these tables will

PREDICT PRODUCT PERFORMANCE

Where does each component of a design fit in these eight categories? The combination is unique, and a strong indicator of the part's ease of assembly and later performance. You can use the same system for other categories of your own—or add to the factors to make them more useful in your own work.

G G QUIRK JR, *engineer, Ordnance Department, General Electric Co, Pittsfield, Mass*

he proof of a good design is in its ease and economy of manufacture and in its successful function. But how do you predict success? Designers apply their experience, training, intuition, with varying degrees of reliability. Accuracy of a prediction is much too dependent on the individual and his prejudices.

The approach described here is an attempt at systematizing a designer's experience and making it available to others as well. I call the system Logic Design Factors and it operates in this way.

We start with the axiom that the identity of any specific item can be determined by using enough general categories to describe it. (For example, in a recent article in PRODUCT ENGINEERING, *Jan* 16, p 61, a specific document is picked out from a stack of 1000 by the four or five basic categories to which it simultaneously and uniquely belongs.)

If we take an assembly and break it down into its component parts, we can describe each part by using general categories. Each will be made up of a certain *material*, have a certain *function*, have a simple *description*, be of a certain *type*, be subjected to a certain *environment*, be *fastened by* a certain method, be made by a series of machining *operations*, and finally have a certain *shape*.

Listed tabularly, the part will have:

1. Material
2. Function
3. Description
4. Type
5. Environment
6. Fastened by
7. Operation
8. Shape

Each of these eight categories comprises a group of terms that describe the part in detail. The number of words in each category is limited because too many words will defeat the purpose of keeping things general. On the facing page are terms I have used with each category:

The eight major categories chosen here are just one engineer's opinion. You may feel some are unnecessary or that important ones are left out. There is no reason why you shouldn't make the changes you see fit.

We now would like to discover what effect the interaction of paired categories has on the product. A matrix can be made which combines every *material* term, for example, with every *function*. Each square in the matrix carries a number indicating relative value.

What is the part made of?

MATERIAL:		
	Iron	Wood
	Steel	Glass
	Aluminum	Nyon
	Copper	Plastic
	Brass	Paper
	Zinc	Rubber
	Tin	

What does it do?

FUNCTION:		
	Connect	Move
	Protect	Turn
	Brace	Rotate
	Enclose	Seal
	Hold	

What word describes it best?

DESCRIPTION:		
	Box	Shaft
	Brace	Gear
	Cover	Plug
	Lever	Tube
	Frame	Fastener

What is it made from?

TYPE:		
	Forging	Block
	Casting	Strip
	Molding	Tube
	Sheet	Extrusion
	Bar-rod	

What type of environment will it face?

ENVIRONMENT:		
	Static	Acceleration
	Pressure	Temperature
	Humidity	Corrosion
	Shock	Stress
	Vibration	Friction

How is it fastened?

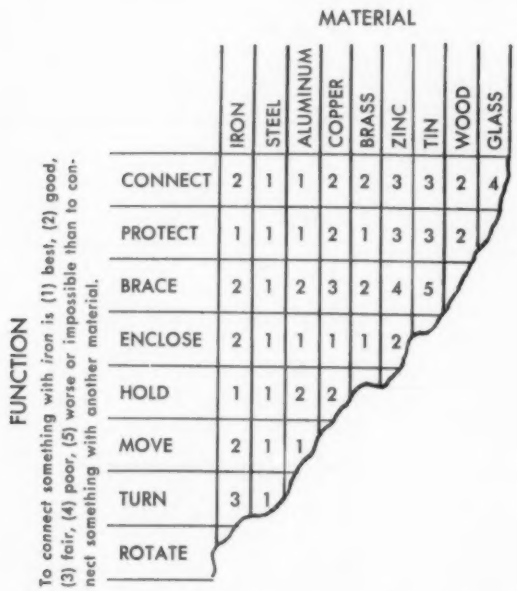
FASTENED BY:		
	Rivets	Solder
	Bolts	Press-fit
	Screws	Pins
	Threads	Glue
	Welds	

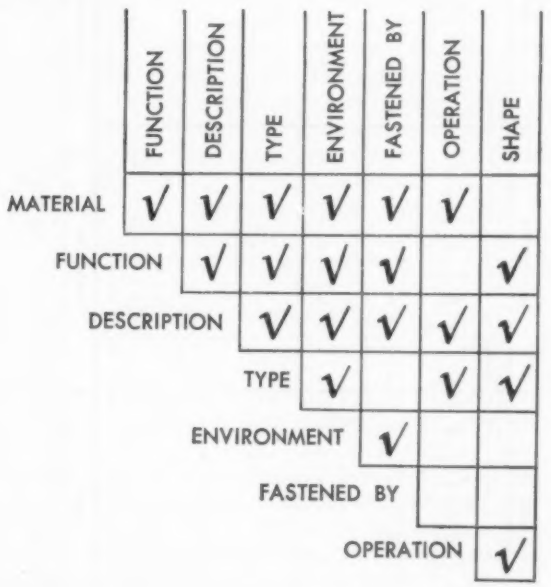
What operations are required to make it?

OPERATION:		
	Drill	Ream
	Turn	File
	Mill	Thread
	Saw	Stamp
	Bend	Roll
	Plane	Form

What is its general shape?

SHAPE:		
	Spherical	Cylindrical
	Cubical	Hexagonal
	Prismatic	Flat
	Rectangular	Oval
	Irregular	


MATERIAL
IRON
STEEL
ALUMINUM
COPPER
BRASS
ZINC
TIN
WOOD
GLASS
FUNCTION
CONNECT 2 1 1 2 2 3 3 2 4
PROTECT 1 1 1 2 1 3 3 2
BRACE 2 1 2 3 2 4 5
ENCLOSE 2 1 1 1 1 2
HOLD 1 1 2 2
MOVE 2 1 1
TURN 3 1
ROTATE
FUNCTION
To connect something with iron is (1) best, (2) good, (3) fair, (4) poor, (5) worse or impossible than to connect something with another material.



Based on experience and judgment, values of from 1 to 5 are placed in the squares. 1 is best; 5 is worst or impossible. Thus any combination of a given *material* with a stated *function* may be evaluated in a more or less automatic way once the matrix has been filled out.

In an exactly similar way, every possible pairing of categories is tried. Eight categories taken two at a time gives 28 possible matrices of which only 21 are significant (*shape* combined with *fastening* could not give significant values, for example.)

So for any new design with known terms for each of the eight categories you can determine and sum the 21 numbers produced by each possible combination of categories. There will be a different total for each component in the assembly and their relative values will indicate the most reliable, easiest to manufacture and assemble component (lowest numerical value) as well as the successively less reliable, more difficult to manufacture and assemble components.

Simple arbor

Now let's test the system on a simple aror. In assembly probably the casting is most likely to cause trouble with mislocated holes or surfaces. If the arbor were run to destruction, in all probability the bushing would fail first, then the shaft. These three parts, then, are the

text continued, page 71

MATERIAL

FUNCTION

To connect something with iron is (1) best, (2) good, (3) fair, (4) poor, (5) worse or impossible than to connect something with another material.

	Iron	Steel	Aluminum	Copper	Brass	Zinc	Tin	Wood	Glass	Nylon	Plastic	Paper	Rubber
Connect	2	1	1	2	2	3	3	2	4	1	2	5	4
Protect	1	1	1	2	1	3	3	2	1	2	2	4	1
Brace	2	1	2	3	2	4	5	1	3	2	2	5	5
Enclose	2	1	1	1	1	2	2	1	1	1	1	1	1
Hold	1	1	2	2	1	2	2	1	3	2	3	5	4
Move	2	1	1	2	2	3	3	2	3	2	2	5	4
Turn	3	1	2	2	2	3	4	4	3	1	2	5	4
Rotate	4	1	2	3	1	4	4	5	4	2	3	5	4
Seal	4	3	3	3	2	4	4	5	3	3	3	5	1

DESCRIPTION

To make a box out of iron is (1) best, (2) good, (3) fair, (4) poor, (5) worse or impossible than to make a box out of another material.

	Box	Brace	Cover	Lever	Frame	Shaft	Gear	Plug	Tube	Fastener
Box	1	1	1	2	2	3	2	1	3	2	2	1	4
Brace	3	1	1	3	2	4	4	2	5	2	3	5	5
Cover	2	1	1	2	2	3	3	2	2	2	2	3	3
Lever	3	1	2	3	2	4	4	3	5	3	4	5	5
Frame	2	1	1	2	2	3	4	2	4	3	3	5	5
Shaft	3	1	2	2	1	3	4	5	3	2	3	5	5
Gear	3	1	2	4	2	4	5	5	5	2	3	5	5
Plug	4	2	2	2	2	3	3	4	2	2	2	4	1
Tube	3	2	2	1	1	2	3	5	1	2	3	5	1
Fastener	2	1	1	2	2	3	3	2	4	1	2	5	4

TYPE

To make a forging out of iron is (1) best, (2) good, (3) fair, (4) poor, (5) worse or impossible than a forging made of another material.

	Forging	Casting	Molding	Sheet	Bar-Rod	Block	Strip	Tube	Extrusion
Forging	2	1	2	2	1	3	4	5	3	4	5	5	5
Casting	1	1	1	1	1	3	4	5	1	2	3	5	2
Molding	1	1	1	2	2	4	4	3	2	3	4	3	1
Sheet	5	1	1	1	1	1	2	1	2	2	1	1	1
Bar-Rod	3	1	1	2	1	3	4	5	1	1	2	5	2
Block	1	1	1	1	1	2	3	1	2	2	2	5	2
Strip	3	1	2	2	1	3	4	4	4	2	2	2	1
Tube	4	2	1	1	1	3	4	5	1	2	2	1	1
Extrusion	5	3	1	1	2	3	3	5	1	2	2	5	1

ENVIRONMENT

An iron part is (1) best, (2) good, (3) fair, (4) poor, (5) worse or impossible in a humid environment than one made of another material.

	Static	Pressure	Humidity	Shock	Vibration	Acceler.	Temp.	Corrosion	Stress	Friction
Static	1	1	1	1	1	1	1	1	1	1	1	1	1
Pressure	3	1	2	3	2	3	4	4	3	2	4	5	3
Humidity	5	4	2	2	3	2	2	5	1	2	3	5	1
Shock	4	2	2	2	3	3	4	3	5	2	3	2	1
Vibration	3	1	1	2	1	2	3	2	4	2	2	3	1
Acceler.	2	1	1	1	1	2	3	2	3	2	2	3	2
Temp.	3	2	2	2	2	3	3	4	3	2	3	5	5
Corrosion	5	4	3	5	4	3	3	5	1	2	5	5	5
Stress	3	2	2	3	2	3	4	3	5	2	3	5	3
Friction	3	2	3	4	3	4	4	5	2	3	3	5	5

FASTENED BY

An iron part fastened by *rivets* is (1) best, (2) good, (3) fair, (4) poor, (5) worse or impossible than a riveted part made of another material.

	Rivets	Bolts	Screws	Threads	Welds	Solder	Press-Fit	Pins	Glue
Rivets	5	1	1	1	2	4	4	5	5	3	4	5	5
Bolts	3	1	2	3	2	4	5	5	5	2	3	5	5
Screws	4	1	2	2	1	4	4	5	5	4	5	5	5
Threads	2	1	2	3	2	4	5	4	4	2	2	5	4
Welds	3	1	2	2	3	4	4	5	1	3	3	5	2
Solder	4	1	3	1	1	1	1	5	4	3	3	5	2
Press-Fit	3	1	2	3	2	4	4	5	2	2	3	5	2
Pins	3	1	2	2	2	4	4	2	2	2	3	5	5
Glue	5	4	4	4	4	5	5	1	3	2	3	1	1

OPERATION

To *drill* a piece of iron is (easier than) (1) best, (2) good, (3) fair, (4) poor, (5) worse or impossible than to drill another material.

	Drill	Saw	Turn	Mill	Thread	Ream	File	Plane	Bend	Shear	Stamp	Roll	Form
Drill	1	1	1	2	1	3	3	1	5	2	2	4	3
Saw	2	3	2	2	2	2	3	1	5	3	3	5	4
Turn	2	1	1	1	1	2	3	1	4	2	2	5	4
Mill	1	2	1	2	1	3	4	4	5	3	3	5	4
Thread	3	1	2	2	1	3	4	4	4	2	2	5	5
Ream	2	1	2	2	1	3	3	4	4	3	3	5	4
File	1	1	2	2	1	2	3	1	5	3	3	5	4
Plane	2	1	1	1	1	2	3	1	5	3	3	5	4
Bend	4	1	1	1	1	1	1	1	5	5	5	5	1
Shear	3	2	1	1	2	2	2	2	5	5	3	2	1
Stamp	4	1	1	2	1	1	1	1	5	5	3	2	1
Roll	4	1	1	1	1	1	1	1	5	5	2	2	1
Form	4	2	1	1	2	1	1	1	5	5	2	2	3

SHAPE

To connect a part with something *spherical* is (1) best, (2) good, (3) fair, (4) poor, (5) worse or impossible than to connect a part with another shape.

	Spherical	Cubical	Triangul'r	Rectang'r	Irregular	Cylindric'l	Hexagon'l	Flat	Oval
Spherical	5	2	4	1	3	4	4	3	4
Cubical	3	1	1	1	1	2	3	4	4
Triangul'r	4	2	1	2	1	2	3	5	4
Rectang'r	1	1	1	1	1	1	1	3	3
Irregular	2	3	2	3	2	3	4	5	4
Cylindric'l	2	1	1	1	2	2	1	1	2
Hexagon'l	3	2	1	2	2	2	2	3	3
Flat	2	2	4	5	3	3	2	4	3
Oval	4	3	4	5	4	4	4	5	4

FUNCTION

To connect something with a *box* is (as good as) (1) best, (2) good, (3) fair, (4) poor, (5) worse or impossible than to connect something with another part.

	Connect	Protect	Brace	Enclose	Hold	Move	Turn	Rotate	Seal
Box	3	1	2	1	1	2	3	4	2
Brace	1	1	1	3	1	2	3	4	3
Cover	3	1	3	1	3	3	4	5	4
Lever	1	3	3	3	1	1	1	2	3
Frame	1	2	1	2	1	3	3	4	4
Shaft	1	3	2	4	1	1	1	1	2
Gear	2	4	3	5	3	1	1	1	4
Plug	4	1	4	1	1	4	4	5	1
Tube	2	3	2	2	2	3	3	3	2
Fastener	1	3	4	3	1	3	3	4	3

TYPE

To connect something with a *forging* is (1) best, (2) good, (3) fair, (4) poor, (5) worse or impossible than to connect something with another type.

	Forging	Casting	Molding	Sheet	Bar-Rod	Block	Strip	Tube	Extrusion
Forging	1	1	1	2	1	1	1	2	2
Casting	3	1	2	2	1	2	2	3	4
Molding	3	2	2	2	1	3	2	3	3
Sheet	3	2	4	1	3	2	3	4	2
Bar-Rod	1	2	1	3	1	1	1	1	1
Block	2	1	1	3	1	1	2	4	2
Strip	4	2	5	3	3	3	3	5	4
Tube	2	2	3	1	2	2	1	3	4
Extrusion	2	2	2	2	2	2	3	3	3

ENVIRONMENT

To connect something in a *pressure* environment is (1) best, (2) good, (3) fair, (4) poor, (5) worse or impossible in a pressure environment or some other function is preferable under pressure.

	Static	Pressure	Humidity	Shock	Vibration	Acceler.	Temp.	Corrosion	Stress	Friction
Static	1	1	1	1	1	1	1	1	1	1
Pressure	3	3	1	3	2	3	2	3	4	4
Humidity	1	3	1	3	1	1	2	3	3	3
Shock	3	3	4	3	2	3	3	3	3	3
Vibration	3	3	4	2	2	1	2	3	3	3
Acceler.	1	1	1	2	1	2	1	2	3	3
Temp.	1	3	1	2	1	1	2	2	4	4
Corrosion	2	4	2	4	3	3	4	4	4	4
Stress	3	2	2	3	2	2	3	3	3	3
Friction	2	2	1	1	2	3	3	4	2	2

FASTENED BY

To connect a part with *rivets* is (1) best, (2) good, (3) fair, (4) poor, (5) worse or impossible than to connect a part with another way or some other function is best served by rivets.

	Rivets	Bolts	Screws	Threads	Welds	Solder	Press-Fit	Pins	Glue
Rivets	3	3	3	5	2	3	5	4	3
Bolts	1	2	2	5	1	2	4	3	3
Screws	2	2	2	5	1	2	4	3	3
Threads	2	2	3	4	1	2	4	2	3
Welds	1	1	1	3	1	3	4	5	1
Solder	3	2	3	3	1	4	4	5	2
Press-Fit	4	2	5	1	1	5	4	5	2
Pins	3	2	4	3	1	2	2	4	3
Glue	4	3	5	5	1	5	5	5	1

SHAPE

To connect a part with something *spherical* is (1) best, (2) good, (3) fair, (4) poor, (5) worse or impossible than to connect a part with another shape.

	Spherical	Cubical	Triangul'r	Rectang'r	Irregular	Cylindric'l	Hexagon'l	Flat	Oval
Spherical	5	2	4	1	3	4	4	3	4
Cubical	3	1	1	1	2	3	4	4	4
Triangul'r	4	2	1	2	1	2	3	5	4
Rectang'r	1	1	1	1	1	1	1	3	3
Irregular	2	3	2	3	2	3	4	5	4
Cylindric'l	2	1	1	1	2	2	1	1	2
Hexagon'l	3	2	1	2	2	2	2	3	3
Flat	2	2	4	5	3	3	2	4	3
Oval	4	3	4	5	4	4	4	5	4

DESCRIPTION

TYPE

A box made from a *forging* is (1) best, (2) good, (3) fair, (4) poor, (5) worse or impossible than a box made from another type.

	Box	Brace	Cover	Lever	Frame	Shaft	Gear	Plug	Tube	Fastener
Forging	2	1	1	1	2	1	2	1	2	3
Casting	1	1	1	1	2	3	4	2	3	4
Molding	2	2	2	1	3	3	4	1	2	3
Sheet	1	3	1	2	3	5	4	5	2	2
Bar-Rod	5	1	5	1	3	1	2	1	3	1
Block	1	1	2	2	1	3	4	3	4	2
Strip	3	2	1	2	4	5	5	5	4	2
Tube	3	2	4	2	3	1	3	5	1	2
Extrusion	5	1	2	1	4	1	2	1	1	1

ENVIRONMENT

A box stands on (1) best, (2) good, (3) fair, (4) poor, (5) worse or impossible in a shock environment than another part.

	Static	Pressure	Humidity	Shock	Vibration	Acceler.	Temp.	Corrosion	Stress	Friction
Static	1	1	1	1	1	1	1	1	1	1
Pressure	2	1	2	1	2	1	3	2	3	1
Humidity	2	1	3	1	4	4	4	3	2	3
Shock	3	2	2	3	4	4	5	3	3	2
Vibration	3	2	3	1	3	4	5	3	2	3
Acceler.	1	2	3	1	2	1	2	2	1	2
Temp.	3	2	3	1	3	3	3	4	2	1
Corrosion	3	2	3	2	3	4	5	4	3	4
Stress	2	2	3	2	5	4	5	3	3	3
Friction	1	1	2	1	3	4	5	5	3	3

FASTENED BY

To *rivet* a box is (1) best, (2) good, (3) fair, (4) fair, (4) poor, (5) worse or impossible than to fasten it in another way.

	Rivets	Bolts	Screws	Threads	Welds	Solder	Press-Fit	Pins	Glue
Rivets	2	3	2	3	4	5	3	5	4	1
Bolts	1	1	1	1	2	3	1	3	3	1
Screws	1	2	2	2	3	3	2	4	3	1
Threads	2	3	3	2	3	3	2	3	2	2
Welds	1	1	1	1	1	2	1	1	1	1
Solder	2	4	2	3	3	3	3	2	3	2
Press-Fit	3	4	3	4	4	4	2	1	3	3
Pins	2	3	2	3	3	2	1	3	2	1
Glue	1	5	3	5	5	4	3	4	3	2

OPERATION

To *drill* a box is (easier than) (1) best, (2) good, (3) fair, (4) poor, (5) worse or impossible than to drill another part.

	Drill	Saw	Turn	Mill	Thread	Ream	File	Plane	Bend	Shear	Stamp	Roll	Form
Drill	2	1	1	1	2	2	2	3	3	3
Saw	2	1	2	1	3	1	3	4	2	3
Turn	4	2	2	1	4	1	1	1	1	1
Mill	2	1	1	1	2	3	4	5	3	2
Thread	5	3	5	2	5	1	5	2	4	1
Ream	2	1	2	1	2	1	1	2	1	3
File	3	1	2	1	3	1	4	2	1	2
Plane	3	2	2	2	3	4	5	4	3	4
Bend	2	1	1	1	3	5	5	5	4	2
Shear	4	2	2	2	5	4	5	5	5	3
Stamp	2	1	1	1	3	5	2	3	4	1
Roll	4	1	2	1	4	1	2	1	1	3
Form	2	1	1	1	4	2	3	1	2	2

SHAPE

A *spherical box* is (1) best, (2) good, (3) fair, (4) poor, (5) worse or impossible than box of another shape.

	Spherical	Cubical	Triangul'r	Rectang'r	Irregular	Cylindric'l	Hexagon'l	Flat	Oval
Spherical	3	5	5	5	5	5	5	5	3
Cubical	1	2	3	3	1	5	4	3	5	5
Triangul'r	3	3	3	4	4	5	5	4	5	5
Rectang'r	1	1	1	1	1	5	5	3	2	3
Irregular	2	2	2	2	1	4	4	4	4	2
Cylindric'l	2	1	4	1	3	1	1	1	1	1
Hexagon'l	3	2	4	2	3	4	4	3	4	2
Flat	5	3	1	2	4	4	2	3	3	2
Oval	3	4	1	4	5	4	5	4	3	4

ENVIRONMENT — A forging stands up (1) best, (2) good, (3) fair, (4) poor, (5) worse or impossible in a pressure environment than another type.

	TYPE								
	Forging	Casting	Molding	Sheet	Bar-Rod	Block	Strip	Tube	Extrusion
Static	1	1	1	1	1	1	1	1	1
Pressure	1	1	2	2	1	1	3	2	2
Humidity	2	3	3	3	2	1	2	2	2
Shock	1	3	2	3	2	1	3	3	2
Vibration	1	3	3	3	2	1	3	2	2
Acceler.	1	2	2	3	1	1	3	2	1
Temp.	2	2	3	3	2	1	3	2	2
Corrosion	2	3	3	4	3	2	3	2	3
Stress	1	2	3	3	2	1	3	2	2
Friction	2	3	3	3	2	1	3	2	3

OPERATION — To drill a forging is (easier) (1) best, (2) good, (3) fair, (4) poor, (5) worse than to drill another type or to operate in some other way on a forging.

Drill	2
Saw	3
Turn	2
Mill	2
Thread	2
Ream	2
File	3
Plane	2
Bend	4
Shear	2
Stamp	3
Roll	4
Form	3

SHAPE — A spherical forging is (1) best, (2) good, (3) fair, (4) poor, (5) worse or impossible to drill another shape or made from some other type.

Spherical	2
Cubical	2
Triangul'r	4
Rectang'r	1
Irregular	2
Cylindric'l	2
Hexagon'l	2
Flat	1
Oval	2

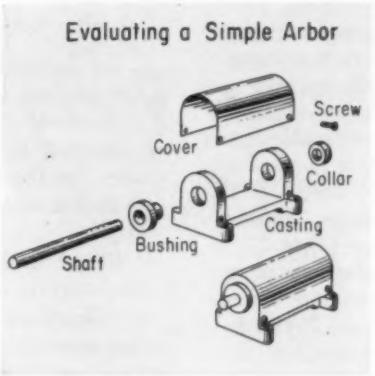
FASTENED BY — A part fastened by rivets is (1) best, (2) good, (3) fair, (4) poor, (5) worse or impossible in a pressure environment than a part fastened by another method.

	ENVIRONMENT								
	Static	Pressure	Humidity	Shock	Vibration	Acceler.	Temp.	Corrosion	Stress	Friction
Rivets	1	2	3	3	3	1	2	3	3	2
Bolts	1	1	2	2	4	1	2	3	2	1
Screws	1	2	3	2	4	2	3	3	3	2
Threads	1	2	3	2	3	1	2	3	3	2
Welds	1	1	1	2	2	1	1	2	2	1
Solder	1	3	2	4	3	1	3	4	4	3
Press-Fit	1	3	4	3	4	3	4	4	3	3
Pins	1	3	3	4	3	3	3	4	4	2
Glue	1	4	3	4	4	3	4	5	4	5

SHAPE — To drill a spherical shape is (easier than) (1) best, (2) good, (3) fair, (4) poor, (5) worse or impossible than to drill another shape.

	OPERATION													
	Drill	Saw	Turn	Mill	Thread	Ream	File	Plane	Bend	Shear	Stamp	Roll	Form
Spherical	3	4	4	5	5	5	4	5	5	5	5	5	4
Cubical	1	1	3	1	5	4	1	2	3	4	2	4	3
Triangul'r	3	3	4	3	5	5	2	3	4	5	5	5	4
Rectang'r	1	1	1	1	4	4	1	2	1	3	1	5	1
Irregular	2	2	3	2	4	3	1	3	2	3	1	1	2
Cylindric'l	2	1	1	3	1	1	2	2	1	4	4	1	1
Hexagon'l	1	1	1	2	5	5	2	3	2	4	3	4	2
Flat	1	1	4	1	5	4	1	1	1	1	1	3	1
Oval	4	3	4	4	5	5	4	5	5	4	4	5	4

	Casting	Bushing	Shaft	Collar	Screw	Cover
MATERIAL	Iron	Brass	Steel	Steel	Steel	Steel
FUNCTION	Brace, hold	Rotate	Rotate	Hold	Hold	Protect
DESCRIPTION	Frame	Plug	Shaft	Plug	Fastener	Cover
TYPE	Casting	Casting	Bar-rod	Bar-rod	Bar-rod	Sheet
ENVIRONMENT	Temperature	Friction	Friction	Vibration	Static, pressure	Static
FASTENED BY	Bolts	Press-fit	Press-fit	Press-fit	Screws	Screws
OPERATION	Mill, drill, ream	Drill, ream	Turn	Drill, turn	Turn, thread	Drill, form
SHAPE	Irregular	Cylindrical	Cylindrical	Cylindrical	Cylindrical	Flat



critical parts, and the screw, collar and cover are not.

This chart lists the terms for each category that describe the various components of the simple arbor.

Now go to the master chart of numbers and choose one number from each matrix. For example, the bushing material is brass, its function is to rotate. That particular *material-function* square contributes a 1 to the total. Where two or more squares are involved in a single matrix (the iron casting has two functions: to brace and to hold) choose the highest numbered square.

Total scores for this assembly's components are:

Bushing: 50 Shaft: 38 Cover: 26
Casting: 43 Collar: 31 Screw: 24

Our original guesses are borne out. The bushing has the highest value, and is therefore the most critical part. The casting is next, and then the shaft.

At this point we must stop and review what we have done. The categories and their numerical values are mine, based on my experience, logic and judgement. They need not be correct in any absolute sense.

To set up any such system of categories requires careful analysis of just what it is you wish to evaluate. A measure of reliability, for example, might need less emphasis on *operation* (by a weighting factor?) and *shape* —more on *environment* and *function*. Ease of manufacture might need just the reverse modification.

Then with a set of categories you feel to be most important (the fewer the better, incidentally) break down each major heading into its individual terms—sufficient to cover but not so exhaustive as to lose significance.

Pair off all categories in a table like that on page 69 and establish which combinations are significant. Make up an individual matrix for each significant combination of categories and fill in all the numerical values.

Try a few sample designs to test the relative scores that result—and then let me, or the editors of PRODUCT ENGINEERING, know how you come out. Ultimately perhaps we can program the matrices on a computer to give quick, reliable totals.

Leaktight seals for

HIGH-PRESSURE VALVES AND PIPING

Today's high hydraulic and pneumatic pressures (up to 6000 psi is not unusual) are a challenge to design. This article compares practical methods for keeping the fluid safely inside the system.

R W ENGLE, *chief engineer, Combination Pump Valve Co, Philadelphia*

It is easy enough to find valves and piping connections for service below 1500 psi and at moderate temperatures. A good search through manufacturers' catalogs will turn up the ones you need. But what about other conditions? Above 275 F, most of the flexible sealing materials become unsuitable. How to design for these higher temperatures has been discussed previously (see Editor's note). In this article, let us examine answers for the higher pressures—in the moderate-temperature range from −20 to 275 F.

Above 1500 psi the choice among standard components begins to narrow—special designs are necessary (for example, the 6000-psi valve shown on page 74). Above 6000 psi, valves and fittings are often custom-made.

The essential problem is to maintain a completely leaktight system. There is no such thing as a "small" leak in high-pressure technology. To accomplish leaktightness, self-sealing seals (where line pressure augments the sealing action) are usually mandatory.

HIGH-PRESSURE PIPING

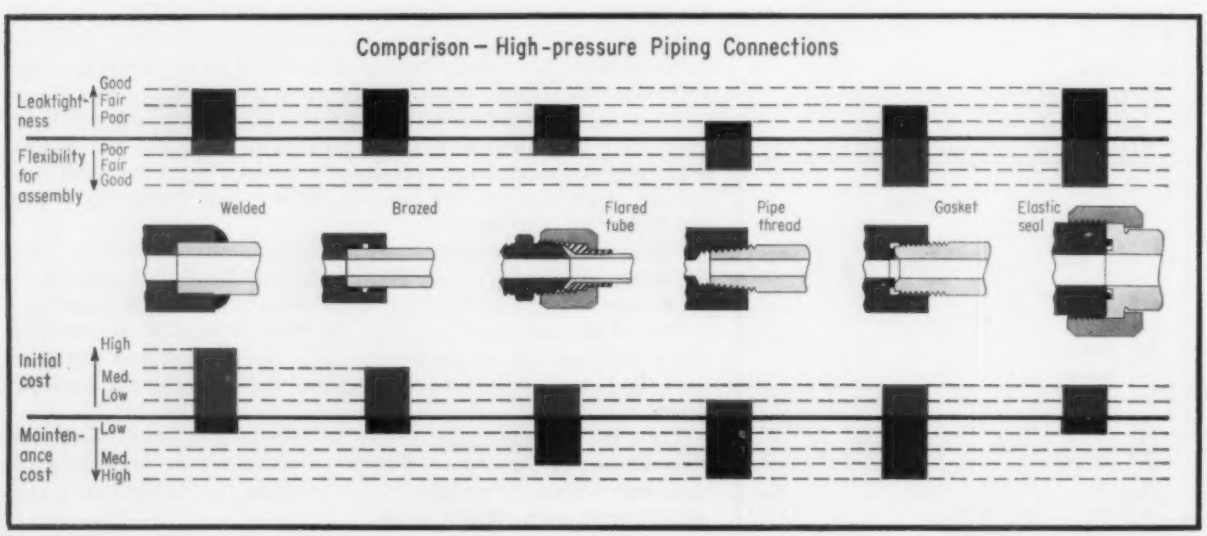
An important problem in any high-pressure system is the selection of connections. Let's take a look at those in common use:

Welded or brazed connections are of course dependable, but the system itself is not easily modified. Also, distortion caused by the heat of welding presents difficulties.

Flared tubing is easily installed and provides good service in the smaller sizes—½ in. OD at 5000 psi.

Pipe threads are adequate at pressures below 3000 psi, but require periodic maintenance. Also, small dirt particles can prevent good sealing, and excessive torque applied to a fitting may distort it.

Gasketed joints contain the pressure by physically opposing it and do not meet the requirement of "self-sealing." However, gaskets are used in many high-pressure



applications; strict compliance with rigorous ASME recommendations can assure leaktightness, but the joints are very bulky.

Elastic seals such as O-rings are ideally suited for sealing high pressure in fixed (static) joints. They are designed to be self-sealing (the line pressure augments the sealing force) and can withstand vibration, flexing and pressure surges which are detrimental to other types of joints. Troubles, if they occur, are usually from misapplication or careless assembly: operating at temperatures that are above rated value; using the wrong-size O-ring; and damaging the elastic or metal surfaces. With care, a custom-designed O-ring sealed joint can retain 50,000 psi without leakage, and no periodic tightening is required.

VALVE SELECTION

The chief problem with valve operation is leaking at the seat and stem. At moderate pressures (below 1500 psi), there are many satisfactory valve and seal configurations. Above 1500 psi, many of the conventional designs are not suitable, and only a few are recommended for leaktight service.

Gas is much harder to seal than liquid at high pressures. Metal-to-metal seats and V-ring stem packing, a satisfactory combination for hydraulic service, are not suitable for gas service. Here's why:

Valve seats and disks

Sealing of two mating surfaces depends on the "perfection" of contact. Any imperfections become channels through which gas can permeate. A soft seat or disk can seal perfectly because it can deform to match the imperfections.

Do not compare or confuse high-pressure gas service with steam service. Steam valves require hardened metal-to-metal seats to resist effects of high temperature and erosion. High-pressure gases are also erosive to valve seats, but hardened metal surfaces will not withstand the "cold shock" of gas expansion from 1000's of psi. Temperature drop at valve seat is rapid, and the seat will develop surface cracks.

Soft-seated valves can withstand very high pressures if designed with large sealing areas (line contact is not enough). Soft seats are necessary in high-pressure gas service because their resilience reduces wear from abrasives, softness permits imbedment of metal particles without loss of leaktightness, and sudden temperature changes are not likely to crack the surface as in some hardened metal seats.

Plastics such as nylon are suitable materials for soft-seated valves. Important considerations are strength, resilience, cold flow, erosion and low temperature brittleness.

Above 6000 psi, metal-to-metal seats are often necessary because elastic or plastic materials do not have the strength required. However, there are disadvantages: abrasive wear, surface cracking under thermal shock, and incomplete imbedment of particles that may jam between the metal seating surfaces. Valves operating over 6000 psi are usually of small size however, and extra torquing will usually make the metal-to-metal seal entirely tight.

Stem packing

For a high-pressure valve, this packing must remain leaktight during motion. Ordinary packing glands that have to be mechanically tightened to withstand the pressure are not usually satisfactory because of wear that appears in packing and stem, particularly when the fluid is a gas. And if a small leak starts, the packing must be tightened still further.

Commonly, high-pressure stem seals are V-rings or molded-shape packings. These can perform satisfactorily if they are designed and installed in a manner to prevent extrusion into the stem-to-bore clearance, and friction on the valve stem from high bearing pressures.

O-rings will not make satisfactory high-pressure stem

TYPICAL SEALS FOR HIGH PRESSURES (temperature from —20 to 275 F)

Pressure Range, psi	Valve Seat	Valve Stem	Pipe Connections (separable only)
300–1500	Most valve types suitable. Soft-seat disks better for ½-in. valves and larger	V-ring and other molded-shape packing	Most methods suitable. Elastic seals preferred (O-rings, etc.)
1500–6000	For gas: soft seat (with area contact, not line contact) For liquid: soft seat for ½-in. valves and larger; either soft seat or metal for small valves	For gas: special stiff packing, pressure-sealed (see text) For liquid: same as for gas recommended; V-ring or molded-shape also suitable	Elastic seal (O-ring, etc.)
6000–15,000	At these pressures, service is special and the valve should be custom-designed		

Why High Pressure Needs Watching

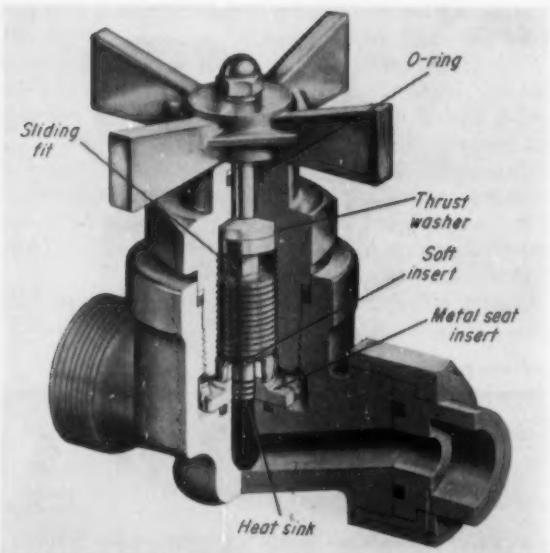
■ It took a mystery—The Case of the Slow-Motion Bullet—to convince one engineer that high-pressure air is a unique fluid. He was running a test on a pressure vessel filled with 4000-psi air; inside it he had mounted a remotely triggered gun. The bullet was fired point-blank to rupture a plate three inches away, but it merely dented it. After four unsuccessful tries, somebody figured out why the bullets lost their punch: air at 4000 psi is as dense as balsawood!

These other examples show problems that are more typical:

• Water at 3000 psi leaked past a valve seat (see photo at right) and impinged with such force on a metal rib that it ate through in three hours.

• Air at 4000 psi expanded suddenly (through a quick-opening valve) against atmospheric air trapped in a closed pipe. The compression temperature was enough to ignite oily residue inside the pipe, causing an explosion—"dieseling." Temperatures up to 1400 F have been recorded.

• Dust-laden air at high pressure has frequently eroded hard metal surfaces of valves and fittings—yet surfaces of nylon and other elastomers can withstand such abuse. Why? Tombstone makers have known the answer for years—when they use a rubber templet to mask the letters being sand-blasted into the stone, it is because the rubber is resilient and "gives" instead of wearing. ■



6000-PSI VALVE for liquid or gas service (designed by CPV Co) combines several features discussed in text: O-ring in tailpiece is self-sealing; union fitting enables valve to be inserted and removed without "springing" the piping (O-ring can seal high pressures even if union is only hand-tightened); soft insert in valve "disk" is nylon; heat sink is a metal button protruding through the nylon disk. It protects disk from heat of compression and also helps retard initial flow to avoid rapid pressurization and "Dieseling"; sliding fit of non-rising square stem lets threaded plug rise to open valve; thrust washer of Teflon serves dual function—reduces friction and does the high-pressure sealing (the O-ring seals when pressures are 500 psi or less).

seals because they are subject to extrusion and tend to grip the stem, causing failure of the O-ring surface.

One answer is the combination seal shown in the 6000-psi valve at the left. In it the O-ring does the sealing at low pressure—up to 500 psi. As pressure increases, thrust on the stem shoulder forces it against a nylon or Teflon washer which then becomes the high-pressure seal. The flat washer eliminates the concentration of forces common to shaped packings.

EXAMPLES OF HIGH-PRESSURE VALVES

The illustration on this page shows a 6000-psi WOG (water-oil-gas) valve based on some of the design principles discussed in the article. And for comparison, here are some other high-pressure valve types.

The needle valve is a common type. It is usually limited to small line sizes—less than 1 in.—but effectively withstands fluid pressures of 5000 psi and more with simple metal-to-metal sealing.

Ball valves of various designs are also used in high-pressure service. The metal ball and seat are precision-made to get as much area of contact as possible.

The ball in one unusual design is completely solid, and is dropped or guided into the valve seal—as in a ball check-valve. A mechanism manipulates the ball. The design takes advantage of line pressure to force the ball tightly into its seat. One manufacturer offers such a valve rated up to 50,000 psi.

More commonly, the ball is drilled through to make a flow passage; a quarter-turn of the valve stem will open this passage or close it. Sealing depends on accuracy of

the ball and of the seat. Some are soft-seated with Teflon or other elastic material; others are metal-to-metal with heavy preloading to withstand the pressure. There are many available ways to actuate ball valves.

Shear-seal and similar valves have flat metal-to-metal sealing surfaces. Here, mechanical loading helps withstand the pressure. Accurate machining is required, but the finished valve is fairly leaktight.

A bellows-sealed stem is an interesting feature of a 2500-psi adjustable relief valve made by one manufacturer. The bellows is both a seal and a loading spring; one end is fastened to the valve body, and the other to the stem. Leakage is eliminated because there is no sliding seal. This type of seal is made very stiff and strong to withstand pressures as high as 2500 psi.

EDITOR'S NOTE: A thorough background in seal design is provided in these previous articles:

How to Choose a Dynamic Seal, Mar 20 '61, p 57—Gives details on all types of seals for rotating shafts, including labyrinth, O-ring, V-ring, and compression packings in dozens of configurations.

How to Apply O-rings, Aug '57, p 176—Summarizes effects of fluid pressure, surface finish, eccentricity and elastomer hardness.

How to Select the Right Gasket Material, Oct 3 '60, p 52—A thorough discussion of the mechanics of a bolted, gasketed joint, with useful tables of bolt stress areas, seating stresses for gasket materials and types, and typical cross-sections. Sample problem shows how to design gasket.

Packed Glands for High Pressure, Nov 10 '58, p 94 and Nov 24 '58, p 74—Two-part article describes gland designs suitable to 5000 psi, including soft packings, metal, and combinations.

Metal-fiber Composites, May 30 '60, p 57—Impregnating a metal felt with a compatible soft metal gives an unusual gasket material that will seal 5000-psi air at 1000 F.

Rotating Seals for High Pressure, Feb '56, p 140—Effect of hydraulic balance, structural design, packing and seal-face materials; and selection of seals for severe operating conditions.

High-temperature Seals, Jan '56, p 151—Factors affecting gland design for sealing reciprocating or rotary motion despite heat and pressure.

—Franklin D Yeaple

TYPE YOUR LOGARITHMIC SCALES

Here's a handy way to lay off logarithmic scales with a typewriter.

D S DAVIS, *professor*
Department of Pulp and Paper Technology
University of Alabama

Calibrating a logarithmic scale, without another logarithmic scale as a guide (your sliderule, for example), is not an easy task. Even with log tables, you have to look up the logs of ten numbers and mark them on a linearly calibrated scale.

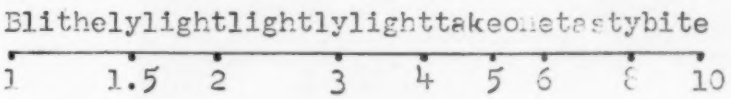
Here's a faster way. Just remember this little verse:

Blithely light, lightly light;
Take one tasty bite

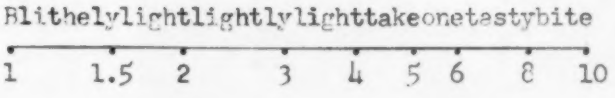
Type it on a typewriter as one line, without spaces or punctuation marks. Now put a mark opposite the last letter of every word and number these 1, 1.5, 2, 3, 4, 5, 6, 8, 10.

Assuming you haven't misspelled any words you now have a logarithmic scale that is correct to about 0.3% over the entire range. With pica type the cycle length is 4.0 in.; with elite type, it's 3.3 in. Because these scales are slightly shorter than half the length of the A scale of a standard 10 in. sliderule, they are often a more convenient length than the sliderule scales and will save calibration of a special scale by proportional construction.

Pica type -- cycle length = 4.0 in.



Elite type -- cycle length = 3.3 in.



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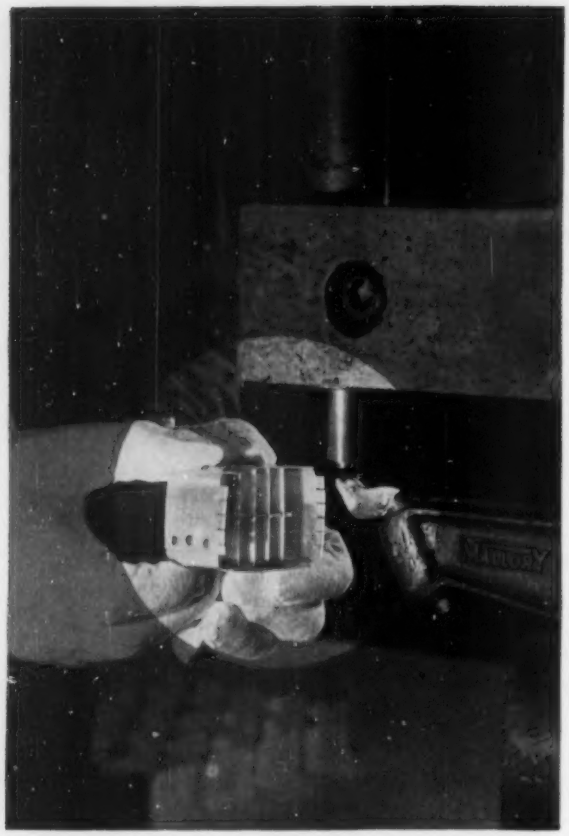


ACCESSIBILITY—a key to faster welding: Crowding in this aluminum assembly required preassembling the internal partitions, then final welding with the offset electrode.

design for FASTER SPOTWELDING

To cut production costs you must reduce production time. This means keeping your eye on several key factors while designing the assembly. These rules will help.

WALTER BLUMENSTEIN, *manager, Spotweld Div, Otto Konigslow Mfg Co, Cleveland*

When you design a spot-welded assembly, you are determining its rate of production as well as its strength and performance. This is because production speed of the assembly will depend on shape of the parts, on number of welds, on where these are placed, and on characteristics of the material being welded.

In normal production, most of the time is spent in positioning the parts; after that the time needed for flow of weld-current itself is only a fraction of a second. An example is welding 0.040-in. steel sheet. An average part might take between one and two minutes. But that includes handling-time. Actual welding time for a spot is only $\frac{1}{6}$ of a second (10 cycles of 60-cycle ac). So, for high-speed spotwelding, welds must be accessible enough to allow the parts to be positioned easily between the electrodes.

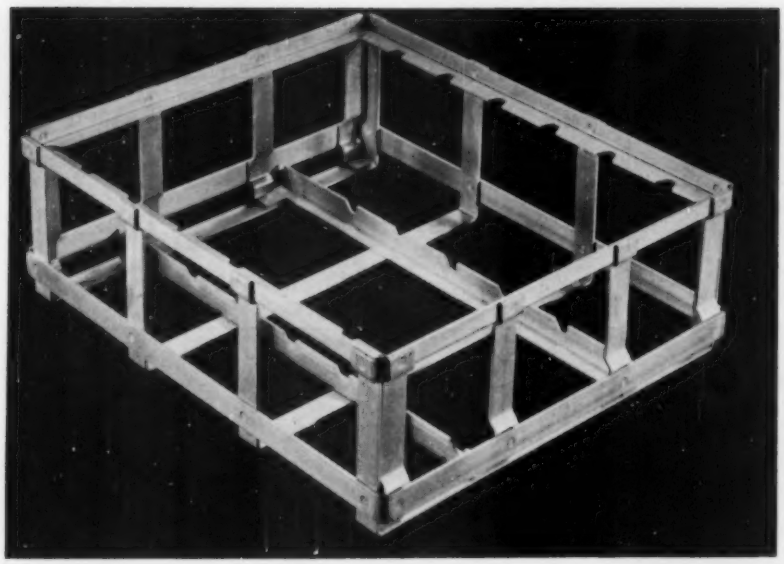
Because the electrodes must make direct contact with both sides of the weld, accessibility depends on shape of the electrodes and their holders. Keep tooling simple and avoid expensive nonstandard weld tips, which may have poorer cooling and therefore shorter life. Don't require the operator to make awkward, time-consuming movements in positioning the parts.

A simple way to check whether a design can be welded by standard tooling is to prepare transparent overlays of standard electrodes and holders, then superimpose these on the drawing of the part.

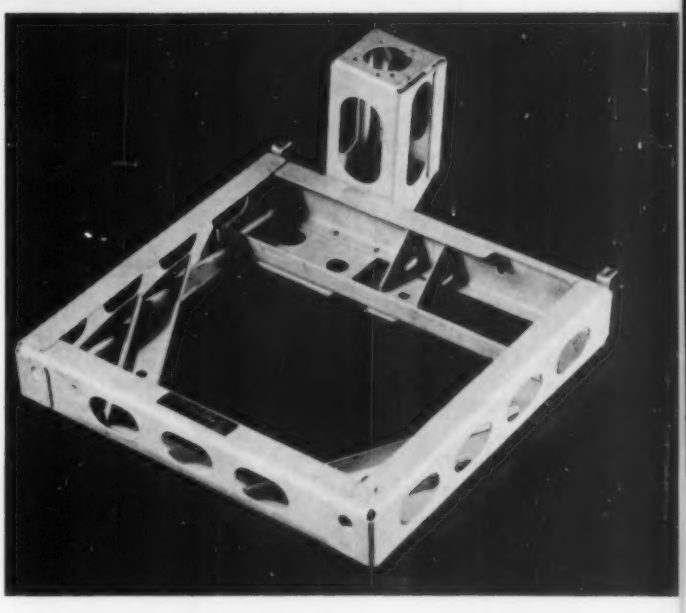
Checklist for good design

Choosing the right design for a spotwelded assembly will be easier if you keep these points in mind.

- Seams on outside of the part should have the necessary electrode clearances. Once the seam is welded, of course, this clearance is no longer needed. This is how to build up complex parts with hidden welds.
- Provide clearance holes directly opposite spot welds, if the joint is otherwise inaccessible. Best access holes are big enough to allow making several welds without threading the electrode through for each weld.
- Back the weld joints in enclosed assemblies with an internal mandrel. Here, weld seams should be arranged so that the mandrel will back up more than one joint at a time.
- Eliminate electrical shunting caused by parts that conduct current away from the weld.
- Ideal thickness of material for spotwelding is from 0.015 in. to 0.5 in. Special equipment is needed for welding



FAST PRODUCTION here resulted from spotweld accessibility, and gave 50% cost savings over former stamped part. The rack was built up of stainless strip and angles assembled, clamped welded and unloaded in 10 man-minutes.



RIGID FRAME ASSEMBLY spotwelded from fabricated sheet. Low-carbon sheet is low cost and easy to weld. Holes reduce weight, provide access for the welding electrodes.

lighter foil or heavier plate. When only two sheets are joined, they can be unequal, with a thickness ratio of 4 to 1 (up to 8 to 1 in special cases). There is no limit to the number of sheets that can be welded together provided each is the same thickness and the stack does not exceed 1 in.

Weld size and spacing

The best weld joint for production is the one with the smallest number of spots, so placed as to give maximum strength. The spot welds should be loaded in shear, be as large as sheet thickness will allow, and be placed for best strength and stress distribution.

The tables for recommended spotwelding practices published by the American Welding Society give much of this design information. Simplified versions of two tables, for low-carbon and stainless steel, from the society's *Welding Handbook* accompany this article. These tables make design calculations easier.

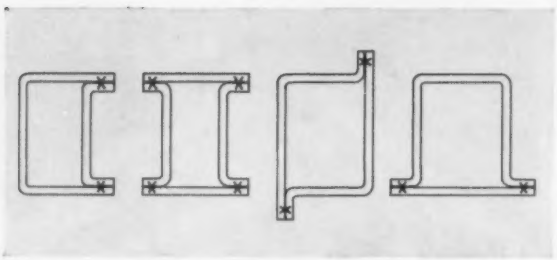
To determine the number of welds and their spacing, divide the required strength of joint by the minimum shear strength for a single spot in that sheet thickness. In a joint with axial loads, this number of welds, spaced evenly, will hold—provided that the space between each spot is greater than the minimum spacing given in the tables.

Spacing less than the minimum recommended will result in weak welds because part of the weld current is shunted through the adjacent spot that has been completed. If the joint is not long enough for adequate spacing, several alternatives are possible:

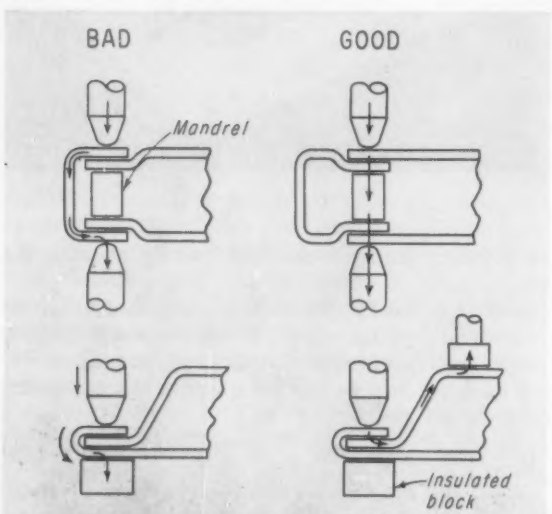
- Widen the overlap and place the welds in a double row. This allows each weld to develop full strength.
- Increase size of the spot by using an oversize electrode and higher weld current. (Increase in strength by this method is limited to about 10%.)
- Weld every other spot, then weld the spot between

RECOMMENDED PRACTICES FOR SPOTWELDING LOW-CARBON STEEL

Sheet Thickness, in.	Min Shear Strength (per spot), lb		Nugget Dia, in.	Min Spacing (center-to-center), in.	Min Contacting Overlap, in.	Electrode Dia, in.	Electrode Force, lb	Weld Time, Cycles (60 cps)
	Ultimate Strength of base metal, psi							
	less than 70,000	more than 70,000						
0.010	130	180	0.10	1/4	3/8	3/8	200	4
0.021	320	440	0.13	3/8	7/16	3/8	300	6
0.031	570	800	0.16	1/2	7/16	3/8	400	8
0.040	920	1200	0.19	3/4	1/2	1/2	500	10
0.050	1350	1350	0.22	7/8	9/16	1/2	650	12
0.062	1850	1850	0.25	1	5/8	1/2	800	14
0.078	2700	2700	0.29	1 1/4	11/16	5/8	1100	17
0.094	3450	3450	0.31	1 1/2	3/4	5/8	1300	20
0.109	4150	4150	0.32	1 5/8	13/16	5/8	1600	23
0.125	5000	5000	0.33	1 3/4	7/8	7/8	1800	26



BOX SECTIONS formed in these patterns make it easy to position electrodes. Formed from sheetmetal, they are lightweight and rigid.



AVOID SHUNTING—Often a simple change like reversing the lap or changing electrode position can eliminate loss of weld strength from shunting.

with higher-than-normal current to offset shunting effect. This technique increases costs because it requires additional handling.

• Choose a thicker material. Strength of each weld is increased although the thicker sheet normally requires even wider spacing between welds.

Parts should overlap by the dimensions shown in the tables to ensure enough surrounding area to contain the molten weld nugget. The clamping pressures used, which can be as high as 3000 psi, are sufficient to squeeze out molten metal from the weld if it is located too close to an edge. Sometimes too little overlap with high weld currents and pressures will actually leave a ragged hole instead of a weld.

The overlapped metal must contact over the entire area without pressure from the electrodes. When the parts do not mate properly prior to welding, a portion of the force is used to clamp the sheets together, leaving insufficient pressure for good welding. This results in blowholes or weak welds.

Clearance for electrodes should be a minimum of $\frac{1}{8}$ in. (Wider clearances are better because they permit faster handling while positioning the part.) This clearance is added to the electrode diameter D in the tables. Normally the electrode tip extends about $3\frac{1}{4}$ in. back into tipholders, which have a diameter of $1\frac{1}{4}$ in. Length of these holders is adjustable, but is normally kept short for better power efficiency.

Materials for spotwelding

Selection of an easily welded material will speed spotwelding—production time may be cut as much as one-

RECOMMENDED PRACTICES FOR SPOTWELDING STAINLESS STEEL

Sheet Thickness, in.	Min Shear Strength (per spot), lb		Nugget Dia, in.	Min Weld Spacing (center-to-center), in.	Min Contacting Overlap, in.	Electrode Dia, in.	Electrode Force, lb	Weld Time, Cycles (60 cps)
	Ultimate Strength of base metal, psi							
	70,000 to 90,000	90,000 to 150,000						
0.010	150	170	0.065	3/16	3/16	3/16	230	3
0.021	370	470	0.10	5/16	5/16	1/4	400	4
0.031	680	800	0.13	1/2	3/8	3/8	650	5
0.040	1000	1270	0.16	5/8	7/16	3/8	900	6
0.050	1450	1700	0.19	3/4	1/2	1/2	1200	8
0.062	1950	2400	0.22	1	5/8	1/2	1500	10
0.078	2700	3400	0.28	1 1/4	11/16	5/8	1900	14
0.094	3550	4200	0.29	1 3/8	3/4	5/8	2400	16
0.109	4200	5000	0.29	1 1/2	13/16	3/4	2800	18
0.125	5000	6000	0.30	2	7/8	3/4	3300	20

half by a seemingly minor change within the same alloy family. Therefore it is important that material be chosen for its spotwelding ability as well as for such requirements as strength, formability, corrosion resistance and high-temperature properties.

Low-carbon steels with less than 0.18% carbon are easiest to weld. Clean cold-rolled steel sheet requires no special preparation and reliable welds can be made in any machine with the necessary current and pressure. Of the steels, these are the easiest to form into complex shapes.

Austenitic stainless steels are the next easiest to spotweld. Their higher resistivity requires less power to weld, but stainless steels need higher electrode pressures and quick weld cycles to avoid precipitating carbides which accelerate grain-boundary corrosion.

Medium- and high-carbon steels are more difficult to weld because they are hardened by the fast cooling rates of spotwelding. As the hardenability is increased by higher carbon content, the steel becomes more difficult to weld, because it now requires special weld cycles to temper. Higher alloy content makes the steel even more difficult to temper. An example is 440C, a hardenable stainless with 12% Cr. This steel requires a long post-heat time, as long as 40 seconds. Some tool steels take so long that they must be put into a furnace to complete the tempering treatment.

Nickel and its alloys (like Monel, Inconel and nickel silver) are easily welded. However, these require precise, synchronous controls, therefore cannot be welded in the simpler welding machines. The newer superalloys in this family are generally more difficult to weld. They are hot-short and tend to crack because some constituents solidify and shrink while others are still plastic and weak.

HOW MATERIALS RATE FOR SPOTWELDING

(in order of ease)

Low-carbon steel	Aluminum
Stainless steel	Magnesium
Nickel and alloys	Hardenable steels
Beryllium copper	Copper

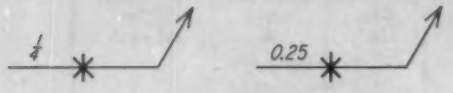
Aluminum and magnesium are more difficult to handle because they have high thermal and electrical conductivity, and need high welding currents and short welding time. In addition, they require precise controls because they soften at welding temperature and must be quickly forged to get a good weld. While the forging movement is small, it must be completed within 2 to 5 millisec because the metals have a narrow melting range and lack a plastic range for forging.

The surface oxide on these metals interferes with welding. Even after removing the oxide, welding usually must be completed within a short time. The surface can also be too clean with insufficient resistance for good welding. These surfaces must form some oxide before spotwelding. Because surface resistance is so critical, cleaning of each alloy must be standardized by accurate surface-resistance measurements. The best aluminum alloys for spotwelding are 5052 and 6061. The softer aluminum alloys are easiest to cold-form but are the most difficult to weld because they are too weak, and mushroom around the molten metal—preventing a sound weld.

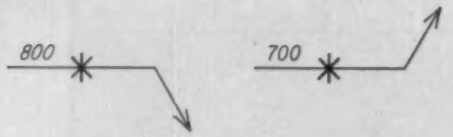
Copper is the most difficult of the common alloys

HOW TO SPECIFY SPOTWELDED JOINTS

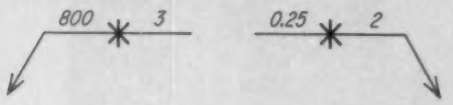
The standard spotweld symbol is an arrow with an asterisk in the center of the body and the head pointing to the weld joint. The tail indicates the weld spec.



Designate size or strength at the left of the asterisk. Nugget size is given in fractions or decimals.

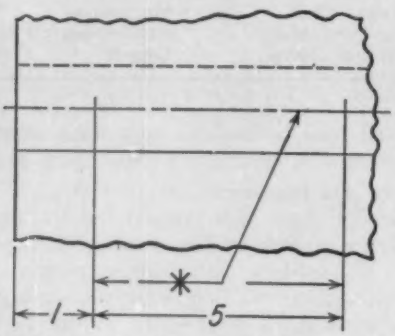


Shear strength for each spot is given at left in lb:

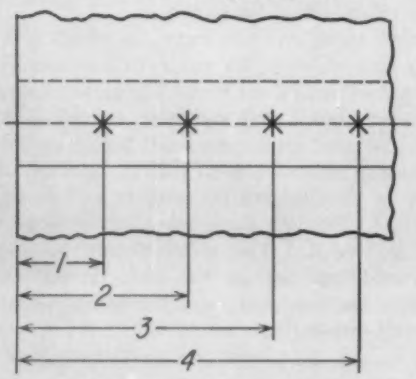


Show center-to-center spacing at right of symbol.

Specify a fixed number of welds above the symbol in ( ).



Show limits of weld area with dimensions when spots extend less than full length of joint . . .



or locate each spot by placing and dimensioning the symbol on the part.

because its high electrical conductivity requires too much power to heat and its thermal conductivity dissipates this heat before welding temperatures are reached. Spotwelding copper is limited to special equipment that synchronizes forging by the magnetic force of the weld current. On the other hand, alloys like beryllium copper, brass, and some bronzes have enough electrical resistance for spotwelding.

Some coated steels like terneplate and tin plate are readily weldable. Zinc-galvanized and aluminized sheet can be welded, but the zinc coating is destroyed at the weld site and some of the aluminum sticks to the electrodes. If not periodically removed, this pickup will cause the electrodes to weld to the part. Prepainting coatings such as Bonderize or Parkerize cannot be welded under any circumstances because they lack conductivity.

Dissimilar-metal combinations are frequently spotwelded. The easiest and the most common is low-carbon steel to stainless or to a hardenable steel. Another readily welded combination is low-carbon steel to a nickel alloy. Aluminum is not weldable to steel by resistance methods. All dissimilar metal combinations should be tested to determine special weld cycles required and what properties can be expected (*PE*—Sep 15 '58, p 82).

Tests for reliability

Even when the material is chosen for easy welding and the assembly is designed for ease of manufacturing, periodic test samples should be made throughout the production run to ensure reliability. This is because destructive test of weld samples is still the most sensitive method of detecting changes that affect weld reliability.

Specify these tests on actual parts rather than on samples of the original material because any forming or heat-treating changes weldability of the metal. Costs can be cut if the test parts are made including any steps that may change the weldability, but skipping the steps that do not affect the metal's properties. Sometimes trimmings or other scrap from fabricated parts make good test specimens.

EDITOR'S NOTE: For additional information on materials and techniques to aid design of strong, reliably welded assemblies, see these recent articles:

New Magnetic Test Includes Stainless Steels, Feb 6 '61, p 41—Particles suspended in a plastic solution measure actual weld-nugget size. Increased sensitivity shows up defects, even in stainless steels that are normally nonmagnetic.

Welding or Brazing Dissimilar Metals, Dec 19 '60—Ways to design to meet leakage at high pressures at integral joints between different metals.

Stronger Parts from Work-hardened Sheetmetal, Oct 26 '59, p 76—How to design weld joints and process the material to take advantage of high mechanical properties of the cold-worked metals.

Also our combined reprint:

Design with Steel—A comprehensive report containing latest design data for a wide range of steels and alloys for high strength and high temperatures. This reprint is available from our Reader Service Dept for $2.

—Herbert Kee

CALCULATES LARGE DEFLECTIONS IN DISKS

This simpler equation for pressure loading does the work of three complicated ones, solving for all possible edge supports—and gives accurate answers for small deflections too.

SYMBOLS

E = Young's modulus, psi
$F_{1,2,3}$ = Diaphragm factors
P = Pressure, psi
R = Radius of plate, in.
t = Thickness of plate, in.
y = Deflection of plate at center, in.

ROBERT I ISAKOWER, *ordnance engineer*
Picatinny Arsenal

Large deflections occur in thin circular plates that sense pressure, and in quick-release devices. Standard handbook equations work for small deflections, but they no longer hold when deflections exceed half the thickness of the plate. The standard equations assume there is no stress in the plane halfway between the top and bottom (neutral surface), but at large deflections there is. This stress, called direct or diaphragm stress, helps carry the load, so it makes the plate stiffer.

To find large deflections you must allow for this stress. Usually this involves complicated equations—one for each of three possible kinds of edge support. But combining several of the terms into a "diaphragm factor" gives this simplified equation for all three cases:

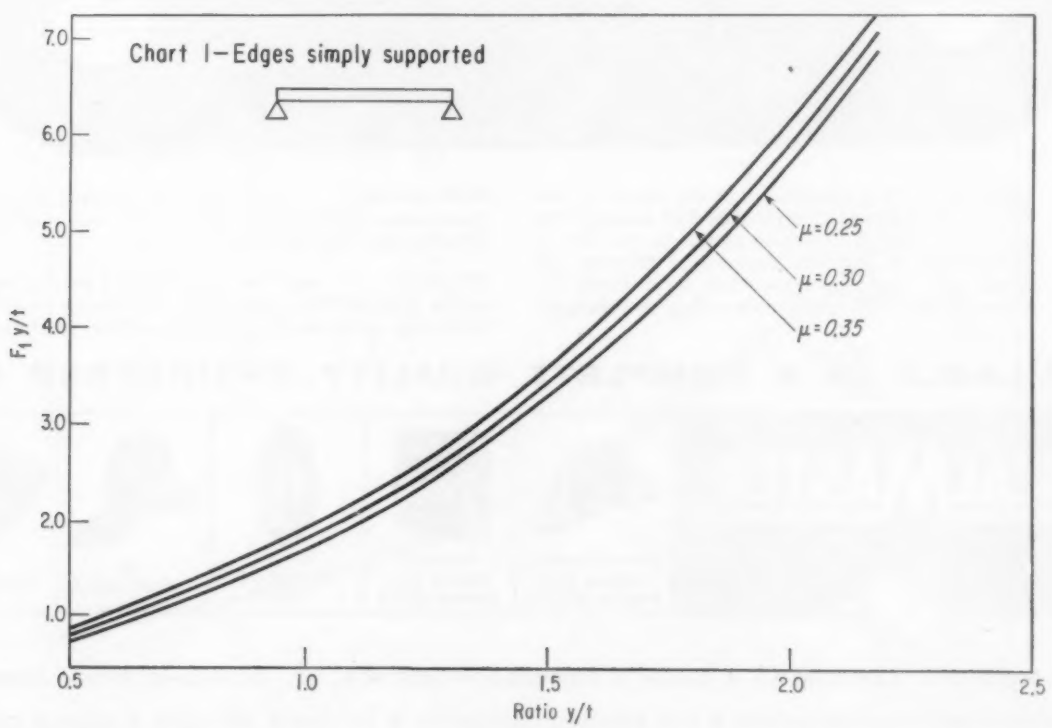
$$P(R/t)^4/E = Fy/t$$

There is a different diaphragm factor for each type of edge support; find the correct value in the charts below and on page 83.

The simplified equation was derived for large deflections, but it gives reasonably accurate answers for small deflections as well. It can therefore be used for all deflection problems.

Example I: What is the maximum deflection of a 0.25-in.-thick circular steel plate with a 20-in. radius, which is under a pressure of 5 psi and is fixed at the edges? Young's modulus $E = 30 \times 10^6$ psi for this steel.

continued on page 83



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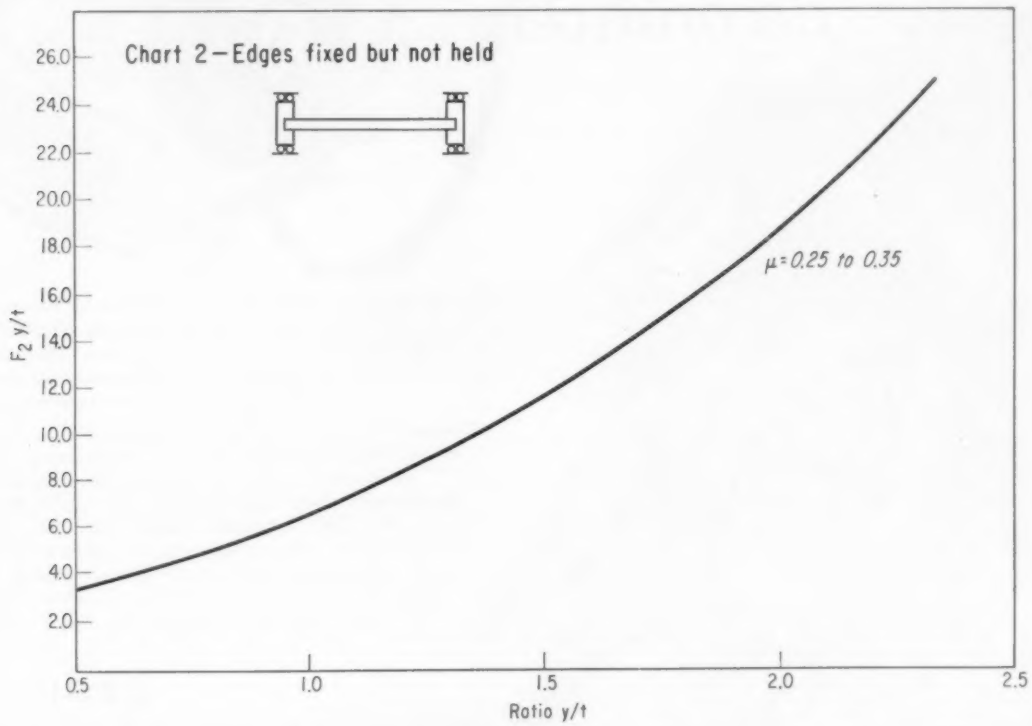
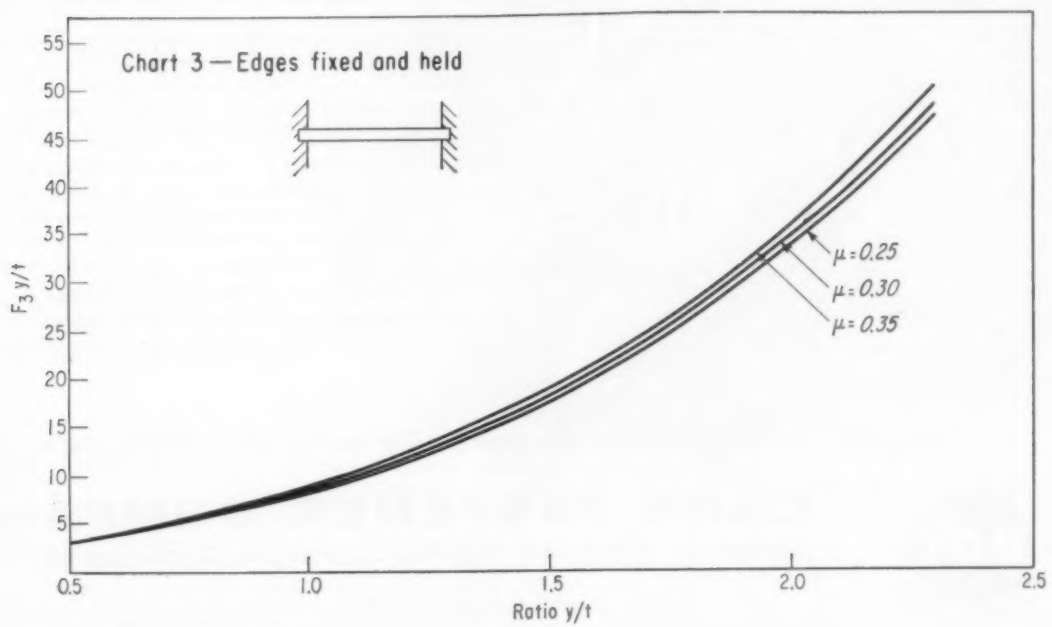
Solution: $F_3 y/t = P(R/t)^4/E = 5\ (20/0.25)^4/30 \times 10^6 = 6.84$. From chart 3, $y/t = 0.87$. Therefore, deflection $y = (y/t)t = 0.87 \times 0.25 = 0.2175$ in.

Example II: If the same plate were simply supported, and deflection were not to exceed 0.350 in., what pressure could the plate stand?

Solution: Ratio $y/t = 0.350/0.250 = 1.4$. From chart 1,

$$P(R/t)^4/E = F_1 y/t = 3.06$$
$$P = 3.06\ E(t/R)^4 = 3.06 \times 30 \times 10^6\ (0.25/20)^4 = 2.24 \text{ psi}$$





DOT PLUG BUTTONS

fill holes functionally and decoratively

Inexpensive DOT Plug Buttons are ideal for covering drilled or molded holes in metal or plastic structures of all types. Finger pressure snaps them into place, spring tension holds them there without rattling even under conditions of severe vibration.

Used as covers for inspection or maintenance-access holes, Plug Buttons are easily removed and can be re-inserted repeatedly without lessening their effectiveness. Used in combination with plastic lens inserts, Plug Buttons make excellent indicator-light covers. Faceted, Fresnel-type or plain lenses can be made in a variety of colors and can be designed to show words, letters or symbols, according to the requirements of the particular application.

DESIGN ENGINEERING SERVICE

Designers, metallurgists and plastics specialists on DOT's engineering staff are equipped to work out optimum combinations of metal and plastics to suit your particular requirements. Hundreds of variations in shape, finish and material are possible.

The basic steel or brass Plug Button, for example, can be parkerized or polished or finished in chrome, nickel, zinc, copper or any of a wide variety of colored enamels. Designs can be stamped into the metal or molded Lucite lenses can be inserted.

Nylon, polystyrene or flexible polyethylene Plug Buttons can be molded to show trademarks, indicator symbols or any other design.

For further details, write for Engineering Data Catalog, Section D

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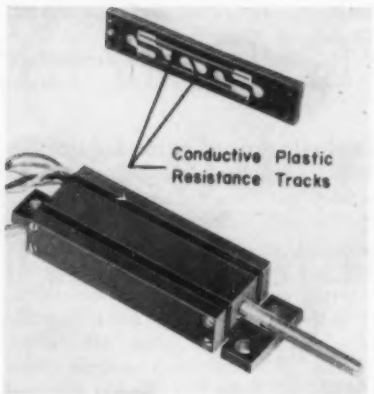
SIGNIFICANT COMPONENTS MATERIALS, PROCESSES



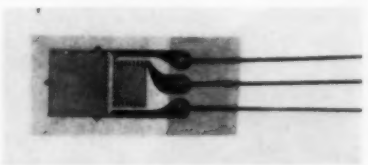
Dual-element potentiometer . . .

has two conductive-plastic resistance tracks, said to offer infinite resolution and long wear life. The electrically isolated, solid raised tracks are integrally co-molded, together with taps and terminals, to an insulator base, made of hi-temp phenolic resin of matched thermal-expansion coefficient. Dual-element feature in rectangular, linear-motion unit is said to satisfy dual output applications, eliminating need for two potentiometers. In complex control systems where both resistance tracks are used for feedback, output of each track can be tailored individually for increased system stabilization. Available with resistances ranging from 250 ohms to 50 k ohms, unit offers independent linearity of ±0.5% or better. Shaft stroke is 1.300 in.; electrical length, 1 in.; and dielectric strength, 1500 v rms. Shorter electrical lengths and other element resistances can be furnished. Unit also is said to have low electrical noise and ability to resist 70 g vibration at up to 2000 cps, as well as shock loading in excess of 100 g without malfunction. Suitable for use in computers, automatic machinery, test equipment and hydraulic systems. From stock. **Markite Corp, 155 Waverly Pl, New York 14.**

Circle 300 on Reader Service Card

Strain gage with built-in computer . . .

solves general strain-to-stress equations automatically. Two sensing elements, oriented 90° apart, permit measuring stress along principal axis and strains in both axial and transverse directions. One element measures the conventional strain; the other acts as automatic computer by rejecting the axial component of strain caused by stress in a transverse direction. Combined elements then respond only to that component of strain which is produced by stress in the axial direction. Available with phenolic base construction and constantan foil—with resistance ratios and temperature compensation for mild steels, stainless steel and aluminum. Three models for use with gage resistances between 60 and 500 ohms or higher have



nominal resistances (element 1/element 2) of 98/350 to 115/350 ohms. Can be bonded with room-temperature curing cements for applications up to 450 F. Priced at $45 per package of five. Delivery in 30 days. **Electronics & Instrumentation Div, Baldwin-Lima-Hamilton Corp, 42 4th Ave, Waltham 54, Mass.**

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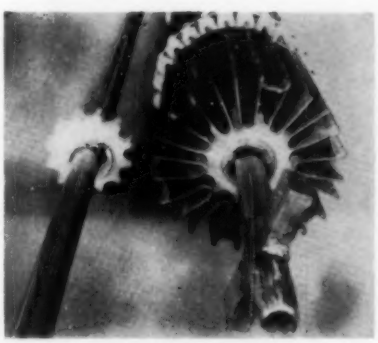

Direct-contact heater . . .

is designed with nickel-chrome ribbon mounted on star-type ceramics in the form of a "V", making it possible to pack as much as 100 kw into a 6-in.-dia section only 7 ft long. Ribbon construction is said to provide better heat transfer since gas being heated flows in direct contact with heating element. Also, more efficient heat transfer results in greater degree of temperature control. Temperature and pressure limitations are determined only by properties of nickel-chrome ribbon itself. Unit is suitable for applications up to 1800 F and in use has withstood pressure of 4500 psi. Can be used on three-phase power with four "V" sections connected in series and three groups of four connected in delta or star. **Hynes Electric Heating Co, 1063 US Route 22, Mountainside, NJ.**

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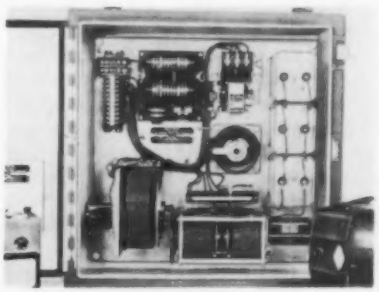

Ac power-compensating transformer . . .

works in conjunction with silicon rectifiers to provide constant but infinitely adjustable motor speeds (ratios up to 100:1) on dc shunt-type motors directly from ac power supply. Unit is nonelectronic and requires no tubes. Automatically regulates voltage and phase angle (thus input power) with change in motor load—acting within ½ cycle of line frequency. Motor, which has thermal protection, can be operated continuously at full-load torque at all speeds and at up to three times full-load torque intermittently. Transformer is available with appropriate motors in 1/50 to 1-hp models. **Vee-Arc Corp, Dept 105, Westboro, Mass.**

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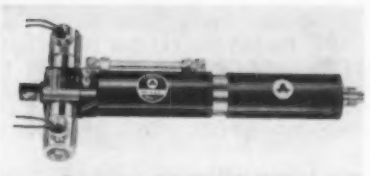

Tandem valve-in-head cylinder . . .

has two pistons mounted on common rod and is designed to combine advantages of valve-in-head cylinder with that of hydrau-

Continued on page 86

lic control. Consisting of valve-in-head and double-acting cylinders mounted in line with common head at center, unit is available in bore sizes of 1½, 2, 2½, 3 and 4 in. and in lengths up to 80 in. Hydraulic fluid can be used either in front cylinder or in middle section of the unit without a makeup chamber. Speed control is obtained by piping flow-control valves in series with ports of the front cylinder filled with hydraulic fluid. Using air pressure in both sections is said to double the force obtainable from standard cylinder of same bore size. **Allenair Corp, 255 E 2nd St, Mineola, NY.**

Circle 304 on Reader Service Card

Pressure transducer . . .

of bonded silicon strain-gage construction, requires no amplifier or associated equipment. Available in pressure ranges from 20 to 10,000 psig and can be overpressured by a factor of 10 without calibration. Accuracy and zero-shift are said to be comparable to wire-gage types. Nominal output resistance is 350 ohms, with max 28 v power required. **Century Electronics & Instruments Inc, 515 S Main, Tulsa, Okla.**

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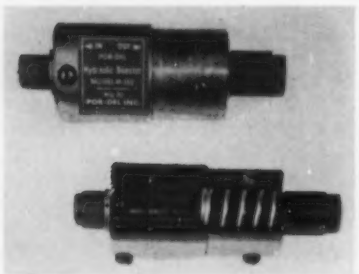

Hydraulic power brake . . .

is self-activating unit (works with engine on or off) that reportedly stops with up to 60% less foot-pedal effort. Attaches remotely or directly to existing master cylinder and is said to provide improved braking, even on systems already using vacuum-type power brakes. Also said to allow better control of brake "fade" at high speeds. Priced from $24.95 to $29.95. **Por-Del Inc, PO Box 1566, Dept 391, Escondido, Calif.**

Circle 306 on Reader Service Card

Low-temp silicone rubber . . .

is designed for use in molded and extruded seals and gaskets and a wide variety of mechanical applications. Material is a gray, 40 durometer, easy processing compound with following typical properties after 24 hr at 480 F: tensile strength of 900 psi; elongation of 400%; and tear strength (Die B) of 65 lb per in. From stock at $4.25 per lb in 1000-lb quantities. **Silicone Products Dept, General Electric Co, Waterford, NY.**

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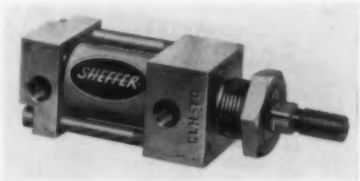


Stud mount cylinder . . .

for 250-psi air and 1500-psi hydraulic service, is 1⅛ sq in. with short over-all length and weighs only 2 lb in 1-in. stroke size. Pistons are made of approx 110,000-psi tensile steel, and piston rods are ground, polished and hard chrome-plated. Cylinder tubes are drawn brass, and assembly is held together with high-tensile-steel tierods, making for prestressed construction. Four wrench flats are standard. Ports are ¼-in. dry seal pipe thread, and jam nut is provided for mounting on ⅜-in. long stud-threaded 1 in. through 14 NF3. From stock in 1-, 2- or 3-in. stroke sizes, with 1-in. stroke, double acting or spring return model priced at $14.95. Other strokes available. **Sheffer Corp, 326 W Wyoming Ave, Cincinnati 15.**

Circle 308 on Reader Service Card

Dual predetermined counter . . .

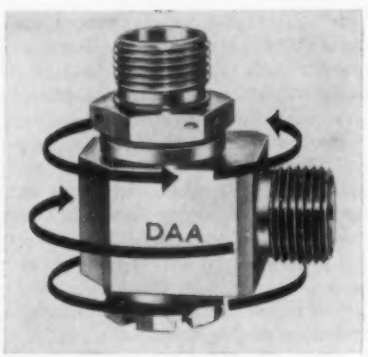
with all-transistor construction, exceeds 100 kc in operation. Has concentric dual control, which enables operator to set to two different numbers. When count from input photocell or other transducer reaches first preset count, a negative pulse is supplied for external control. When second preset number is reached, a second negative pulse is supplied. If reset switch is on "manual," the counter will then stop on last number and will display this count until operator manually or electronically resets system to zero. If reset switch is on "automatic," the counter automatically resets to zero immediately after reaching second preset number. Operates from standard 115-v ac, 60-cps power source and performs equally well at 1 count per hr or 100,000 counts per sec. Input range is less than 1 v to more than 10 v and input impedance, 100,000 ohms shunted with 47 micromicrofarads. Has 1-in.-high, in-plane bright tungsten display. Five models with from 2 to 6 decade displays are priced from $495 to $895. **Robotomics Enterprises Inc, 2422 E Indian School, Phoenix 16, Ariz.**

Circle 309 on Reader Service Card

Explosionproof solenoid valves

control hydraulic systems at pressures up to 2000 psi. Two- and three-way units are stainless steel, direct acting, slide types with 3/32-in. inlets and cylinder orifices with ⅛-in. NPTs. Can be used as two-way normally open or normally closed valves, or as three-way normally closed, normally open or dual-purpose valves. Meet standards for use in hazardous locations. **Skinner Electric Valve Div, Skinner Precision Industries Inc, New Britain, Conn.**

Circle 310 on Reader Service Card



Low-torque swivel fitting . . .

provides 360° rotation and operates at temperature extremes and pressures up to 5000 psi. Assembly is pressure-balanced and reportedly not subject to separation forces. In ¼-in. tube size, torque is less than ¾ in.-lb at 3000 psi, and in 1-in. tube size, less than 4 in.-lb at same psi. **Dumont Engineering Co., 1401 Freeman Ave., Long Beach, Calif.**

Circle 311 on Reader Service Card

Adhesive-backed asbestos tape . . .

is available for services up to 500 F in commercial grades and up to 900 F in other grades. Use in an unsupported structure, however, is limited to 275 F, point at which adhesive begins to lose strength. Supplied in thicknesses of 0.022, 1/32, 1/16 and ⅛ in. and in widths

continued on page 89

Circle 87 on Reader Service Card→

You get more value for the same dollar— in the NEW Bulletin 709 line of starters!

SIZE 00

SIZE 5

Note the compactness of both the smallest and largest starter in the new Bulletin 709 line. Ratings up to 100 hp, 220 v; 200 hp, 440-550 v.

This new line of Allen-Bradley motor control will change every idea you have had about starter size, performance, and life. The small size—especially in the higher ratings—is startling. Yet rating for rating the operating life and reliability have been increased many times. Built into each of the seven sizes of this new Allen-Bradley line is an ability to interrupt tremendous currents and to operate year in and year out for many millions of operations without trouble or maintenance.

The new Bulletin 709 starters are just as advanced in appearance as they are in performance. All seven sizes have an aristocratic styling and a distinctive family likeness. Brooks Stevens, famous industrial designer, has given the enclosures such an attractive, modern style that these new starters will prove a distinct sales asset on any machine or installation.

Why not write today for more information on this revolutionary new line of Allen-Bradley Bulletin 709 *quality* across-the-line motor starters?

10-61-RM

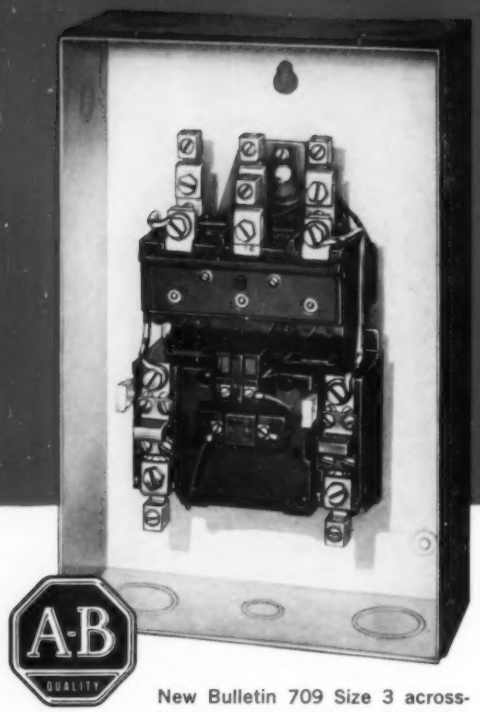
ALLEN-BRADLEY

Member of NEMA

Allen-Bradley Co., 1316 S. Second St., Milwaukee 4, Wis.

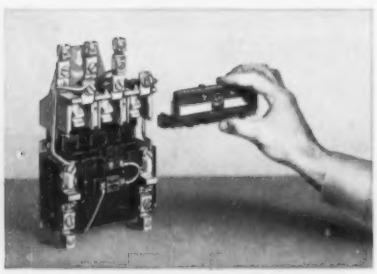
QUALITY MOTOR CONTROL

Features of the NEW Allen-Bradley starter line that are of value to you!

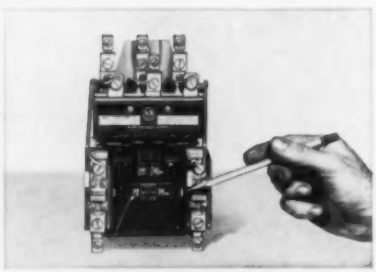


New Bulletin 709 Size 3 across-the-line motor starter. Note the generous space for wiring, accessible terminals, and white interior.

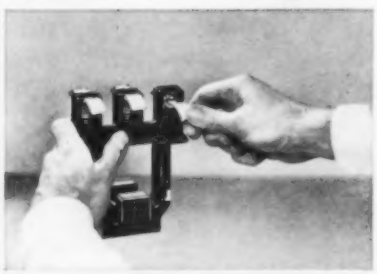
Every detail of the new Allen-Bradley motor starters has been designed to help make this the best line of motor control on the market. Remarkably small in size, each starter is a giant in performance. Being light in weight, these starters are easy to handle and a cinch to install. The generous wiring space, full front wiring, white interiors, and convenient knockouts make installation easy. The enclosure cover is firmly held with a quarter-turn fastener. All installation, inspection, and maintenance operations can be handled from the front—as shown in the illustrations below—without the use of special tools.



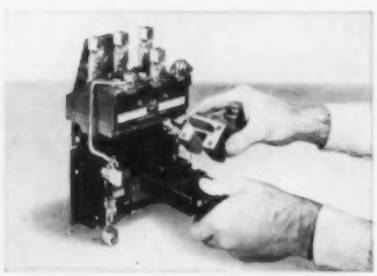
QUICK, EASY CONTACT INSPECTION—When the arc hood front cover is removed by loosening two captive screws, contacts are plainly visible from the front.



CONTACT POSITION INDICATED—Two slots in the coil cover show the position of the movable contact support—tell whether contacts are "closed" or "open."

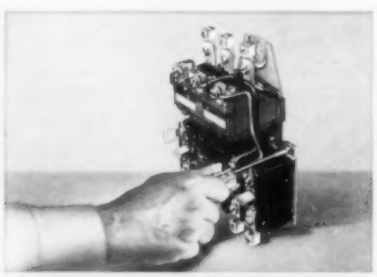


CONTACTS EASILY REPLACED—Depress the spring slightly, and the movable contacts can be lifted out of the molded support and the new contacts slipped in.



COIL EASILY CHANGED—When the coil cover is removed, coil and magnet yoke can be lifted out from the front. They are impossible to replace incorrectly.

AUXILIARY CONTACTS EASILY ADDED to the front of the starter. Two extra auxiliaries can be added to Sizes 0, 1, and 2 starters, and four, to Sizes 3, 4, and 5.



A THIRD OVERLOAD RELAY CAN BE EASILY ADDED in the field, from the front of the starter. And the only tool needed is a common screwdriver.

ALLEN-BRADLEY

Member of NEMA

Allen-Bradley Co., 1316 S. Second St., Milwaukee 4, Wis.

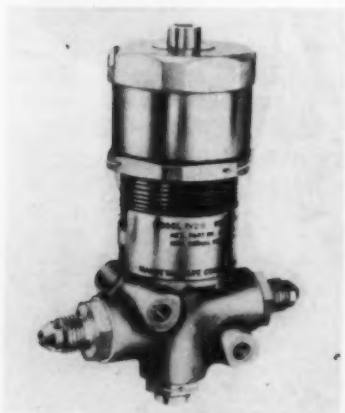
QUALITY MOTOR CONTROL

from ¼ to 6 in. Tapes under ⅛ in. thick are furnished in 50-ft rolls; others in 25-ft rolls. Thickness is nominal thickness of tape, exclusive of adhesive. **Johns-Manville, Packings & Textile Div, 22 E 40th St, New York 16.**

Circle 312 on Reader Service Card

Torque-arm reducer . . .
with 5:1 gear ratio, transmits 50% more hp at output speeds up to 400 rpm than previous models. Shaft-mounted unit accommodate 60-hp motors in top range of output speeds based on Class 1 AGMA ratings. From stock for horizontal shafts at $1285. Units for vertical or inclined shafts on request. **Dodge Mfg Corp, Mishawaka, Ind.**

Circle 313 on Reader Service Card



Set pressure regulator . . .
is high-pressure, small-volume unit incorporating a pressure reducer and an independent, inverted-type relief valve operated by a single actuator. Plastic-coated, frictionless pistons and spring loading are said

continued on page 91

PARCO PROBLEM PROBERS

Consistent O-Ring Quality

The quality and dependability of any pressurized hydraulic or pneumatic control or operating system hinges largely on the leak-proof properties of the seals used to segregate pressure differentials within the system. In many systems, molded rubber "O" Rings are used for this purpose. These "O" Rings must provide a dead-tight seal at all times regardless of operating temperature within the specification range. They must be totally resistant to system fluids or gases and must maintain physical constants throughout their operational life. ○ For many years Parco has been one of the nation's major producers of "O" Rings which meet these varied and rigid requirements. With these two requirements met, resistance to system fluids or gases —resistance to temperature variations, and maintenance of physical constants automatically follows. ○ These features add up to the consistent high quality and leak-proof properties which have made Parco "O" Rings a synonym for failure-free operation.

Send for your latest Parco Slide Rule

Plastic and Rubber Products Company
2100 Hyde Park Boulevard
Los Angeles 47, California

Plastic and Rubber Products Company
2100 Hyde Park Blvd. • Los Angeles 47, Calif.
Please send the Parco O-Ring Data Chart to:

NAME_____
COMPANY_____
BUSINESS ADDRESS_____
CITY_____
ZONE____ STATE_____

WHY THE BIG SWING TO FORD POWER?

Three good reasons

1 **ALL FORD INDUSTRIAL ENGINES** are modern overhead valve design

2 **FORD INDUSTRIAL ENGINE SERVICE** is available **EVERYWHERE**

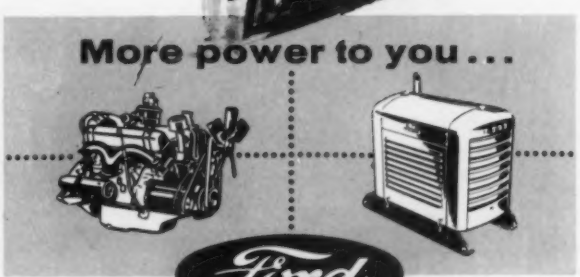
3 **FORD INDUSTRIAL ENGINE PARTS** cost less

Only Ford offers a complete line of modern, overhead-valve-design engines. Ford Industrial Engines range from 134 to 534 cubic inch displacement, including modern diesels. These are *compact* engines, delivering more horsepower per pound of engine weight than ever before possible! And all Ford gasoline engines are short-stroke for greater fuel economy and longer life.

No matter *where* he's located, a Ford industrial power user can count on less downtime . . . because there's always a Ford Dealer nearby to give him service *when he needs it!* Stretching across the country, too, is a complete network of Ford Industrial Products Dealers providing the kind of fast, efficient service that cuts operating costs.

Speaking of cost . . . Ford industrial power users *really* save on engine parts! Due to Ford's high volume production, parts are priced low. And with 26 Ford Parts depots strategically located across the country . . . delivery of those parts is *immediate!*

These are just a few of the reasons why *you* should join the swing to Ford power. Call or write to the address below.



YOUR JOB IS WELL-POWERED WHEN IT'S FORD-POWERED!

Ford
INDUSTRIAL ENGINES AND POWER UNITS

INDUSTRIAL ENGINE DEPARTMENT, FORD DIVISION, FORD MOTOR CO., P.O. BOX 598, DEARBORN, MICH.

West of Rockies write to:
→ FORD INDUSTRIAL ENGINE DEPT., P.O. BOX 6787, LOS ANGELES 22, CALIF.
→ FORD INDUSTRIAL ENGINE DEPT., P.O. BOX 1666, RICHMOND, CALIF.

to allow constantly accurate regulation unaffected by inlet pressure fluctuation or ambient temperature change. Bubble-tight shutoff is achieved by stainless steel valve stem (poppet) and reinforced nylon seats. Inlet pressures range from 500 to 4500 psi and regulated pressures, from 50 to 1500 psi. Typical unit is 4½ x 2 (without fittings) x 1¾ in. dia, weighing less than ¾ lb. Operating temperatures are from −65 to 160 F, with special models up to 250 F. **Marotta Valve Corp, Boonton, NJ.**

Circle 314 on Reader Service Card

Angle position indicator . . . originally designed for use in military field-testers, consists of two individual assemblies—servo indicator and amplifier package. Has accuracy of ±6 min.; direct readout in degrees and minutes; choice of sensors; sensitivity of 1 min.; repeatability of 2 min.; resolution of 1 min.; and slewing speed of 12° per sec. Six models are available, including dual sensor units to measure angles from two independent sources. Amplifier is either vacuum tube or transistor-equipped. **Kearfott Div, General Precision Inc, 1150 McBride Ave, Little Falls, NJ.**

Circle 315 on Reader Service Card

All-metal swivel joint . . . operates within −425 and 1500 F and at 1500-psi pressure (higher if desired). Balanced pressure principle holds swiveling torque to a min—for example, 4 in.-lb at

continued on page 92

WATLOW'S
FIREROD
OUTHEATS...
OUTLASTS...
OUTPERFORMS
ANY OTHER
CARTRIDGE HEATER!

OUTHEATS—because Watlow's FIREROD® produces up to eight times as much heat as any standard cartridge unit—or will give as much heat as a standard unit in ⅛th the space.

OUTLASTS—Watlow perfected the exclusive construction techniques that permits the FIREROD® to operate at lower internal temperatures. Better heat transfer from the resistance wire to the sheath permits high operating temperatures without excessive internal temperatures which cause burnouts. Laboratory and field tests have proven FIREROD'S® superiority when tested with *any other cartridge heater*, including competitive so called "high watts density" units.

OUTPERFORMS—Proven longer life—less replacements and down time—up to 8 times as much heat as other standard units or the same heat in ⅛th the space—and at a price only slightly higher than a standard unit. Deliveries two weeks or less.

WHEN YOU SPECIFY CARTRIDGE HEATERS SPECIFY WATLOW'S FIREROD

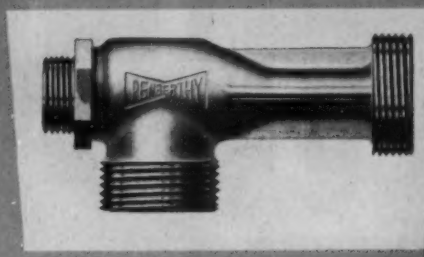
Bulletin 367 will give you complete information.

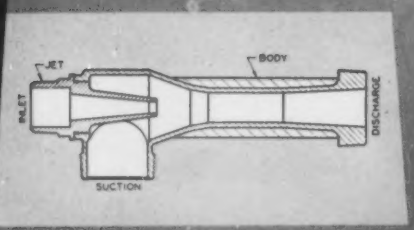
6102

WATLOW
ELECTRIC MANUFACTURING CO.
1392 Ferguson Ave./St. Louis 14, Mo.

VERSATILITY

for applications unlimited





JET PUMPS by PENBERTHY

There's hardly a basic manufacturing or service industry that hasn't a use for Penberthy Jet Pumps. And the list of OEM products embodying Jet Pump applications is virtually endless, too. Small wonder, for wherever there's a fluid, vapor, gas or slurry handling job to be done . . . aerate, agitate, blend, circulate, dilute, exhaust, filter, heat, mix, pump or transfer . . . there you'll find an application for *versatile* Penberthy Jet Pumps.

And consider the advantages . . . small in size, light in weight . . . construction and operation simplicity . . . low initial cost, low installation cost, little or no maintenance cost. And in many cases Penberthy Jet Pumps can be utilized where mechanical pumps are impractical or uneconomical. Want more information? Send the coupon below or call your nearby Penberthy engineer today.

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PROPHETSTOWN, ILLINOIS
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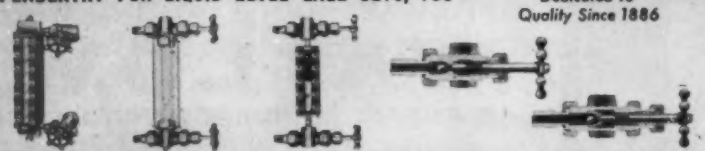
PENBERTHY
Dedicated to Quality Since 1886

PENBERTHY FOR LIQUID LEVEL GAGE SETS, TOO



WRITE OR CALL PENBERTHY TODAY FOR COMPLETE INFORMATION

1500 psi. Bellows are welded metal instead of usual elastomer. **Available in** ¼-in. tube size, with other sizes on request. **Sealol Inc, 197 Post Rd, Providence, RI.**

Circle 316 on Reader Service Card

Zero-speed switches for hazardous areas . . .

are shaft-driven controls consisting of modified standard units enclosed in explosionproof housings. Contacts are SPDT, totally enclosed, snap action types, rated at 10 amp at 125, 250 or 460 v ac; ½ amp at 125 v dc; and ¼ amp at 250 v dc. Designed for driven speeds up to 1800 rpm, they operate within ambient temperature range of —20 to 200 F. Various contact trip-in and drop-out speeds are available. **Winterburn Mfg Co, Putnam, Conn.**

Circle 317 on Reader Service Card

Four-circuit limit switch . . .

has four SPDT basic switches within its 1-in.-dia housing. Available in two actuator designs—plunger model for in-line operating motion and positive-drive rotary linkage unit for operation under adverse dirt and ice conditions. Operating point of rotary linkage can be adjusted by moving lever arm to any position on a full circle. Both models are rated at 24 amp max inrush and 7 amp resistive at 28 v dc. Completely-sealed enclosures are first evacuated, then filled with inert gas, said to assure constant operating characteristics. From stock at $45 to $65. **Micro Switch Div, Minneapolis-Honeywell Regulator Co, Freeport, Ill.**

Circle 318 on Reader Service Card

Reluctance stepper motors . . .

step in small increments of 15 and 7.5 deg at rate of 200 to 550 steps per sec. A logic circuit controls their stepping sequence, rate and direction (can be driven by electromechanical or electronic logic). Reportedly have angular travel

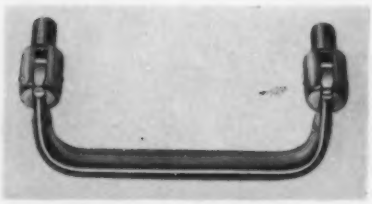
with non-cumulative error, high torque in stop position and frequency-controlled speed. Two available models have following specifications: 1.9 and 2.4 in.-oz stall torque; 0.8 gm-cm² rotor inertia each; —67 to 257 F temperature range each; 26 and 30 v dc voltage requirements; and 0.260 and 0.480-amp current for each winding at stall. **American Electronics Inc, Instrument Div, 9503 W Jefferson Blvd, Culver City, Calif.**

Circle 319 on Reader Service Card

Resistance temperature transducer . . .

has 0.100-in. element dia, which is said to provide a min interruption of fluid flow and to allow the unit to be placed in difficult-to-reach measuring points. Time response is down to 20 millisec or less with tungsten elements. Calibration is repeatable within 0.05% of transducer's resistance value measured at 77 F. Through use of a connector, element is hermetically sealed with pressure rating up to 6000 psi. Its sensitive length is 0.35 in. **Winsco Instruments & Controls Co, 11789 W Pico Blvd, Los Angeles 64.**

Circle 320 on Reader Service Card



Oval folding handles . . .

include 3-position model which folds full 180° against panel and 2-position model which folds 90°. Both 4-in. long handles with positive-locking devices are made of brass and finished in nickel plate or black oxide. Max depth of handle from panel is 1.797 in. From stock at $1.80 in quantities of 250 to 499. **Cambridge Thermionic Corp, 45 Concord Ave, Cambridge 38, Mass.**

Circle 321 on Reader Service Card

Dc voltmeter . . .

uses near-silent reed relays for precision bridge-circuit switching. Transistor-equipped unit covers full dc range from 1 milliv to 999.9 v and includes built-in safety circuit to protect it from input over-voltages. Reads dc voltages with accuracy of 0.01% plus or minus one digit, throughout entire spectrum of instrument's range. In reading voltages, average balance time is 500 millisec and max readout time, 750 millisec. Unit's power input is 105-125 v ac, 50-60 cps, 25 w standby and 3 w operating. Input impedance is 10 megohm at balance and sensi-

continued on page 96

Design Uniform lift into equipment with DUFF-NORTON WORM GEAR JACKS

Many designers find a ready answer to precise control of linear motion in machinery or equipment with built-in Duff-Norton Worm Gear Jacks.

They are used singly, in tandem and in multiple jacking arrangements to position loads weighing from a few hundred pounds to as much as several hundred tons.

When connected in tandem or groups of four, six or more, these jacks always raise or lower in exact unison regardless of load distribution. They are also used for application of pressure, to push or pull and as linear actuators.

Duff-Norton Worm Gear Jacks are self-locking and will hold heavy loads in position indefinitely without any creep. Since there is no fluid or air to leak, the action is always positive and maintenance is no problem.

These jacks are available in eight standard models with capacities ranging from 2 to 100 tons and with standard raises from 6 to 24 inches. Special raises can also be furnished.

To learn more about how Duff-Norton Worm Gear Jacks may be used in your equipment, send for the bulletin which shows engineering drawings of jacks, Duff-Norton Mitre Gear Boxes and typical applications. Ask for AD 66DD.

DUFF-NORTON COMPANY

Four Gateway Center · Pittsburgh 22, Pa.

DUFF-NORTON JACKS
Ratchet • Screw
Hydraulic • Worm Gear

DUFF-NORTON

COFFING HOISTS
Ratchet Lever • Air
Hand Chain • Electric

OHIO RUBBER

"CUSTOMEERED COMPONENTS BASIC TO INDUSTRY"

STAINLESS STEEL JEWELS
make facsimiles by the million!

OHIO RUBBER can, and regularly does produce 100,000 *identical* rubber parts per day from one set of production tooling. The jewel-like precision of the self registering molds shown above–actual size–is a key factor in ORCO's high speed, high accuracy, continuous molding process.

AUTOMATIC INTEGRATION of processing steps which are usually handled separately eliminates variables–provides precise control for achieving the ultimate in product uniformity. **RUBBER PARTS** up to 1½" in diameter and 1" in thickness produced by this process are distinguished by uniformity, minimum flash and precision tolerance of ± .003".

QUANTITY REQUIREMENTS involving not less than 500,000 parts proves best for this new process.

"**DO YOU** use small precision molded rubber parts by the million?", if so, the full story of ORCO "CUSTOMEERED" Continuous Molding is yours via free Bulletin CM-100. Send for your copy today to see how custom molded, precision rubber parts can be produced in volume—at less cost. MP-160

ORCO **THE OHIO RUBBER COMPANY**

General Office • WILLOUGHBY, OHIO • WHitehall 2-0500

A DIVISION OF THE EAGLE PICHER COMPANY

A Tinnerman T-Marked Original...

Dual SPEED NUTS® open door to 20% savings on as-assembled cost

Gibson refrigerator door hinges are held in place with new cost-cutting, time-saving twin-type SPEED NUTS. They replace 3/16" plate hinge retainers which had to be drilled and tapped for machine screws.

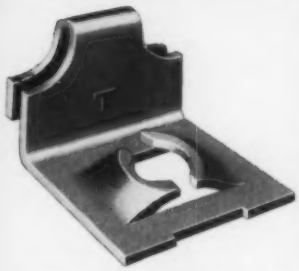
Gibson Refrigerator analysts estimate that special twin-type SPEED NUTS save 14% on the cost of each hinge retainer assembly, 20.5% on the as-assembled cost. Labor is reduced by half. Former problems with cross-threading and stripping are eliminated . . . SPEED NUTS and A-type screws go together naturally every time—and faster!

The T-mark of quality and dependability identifies the more than 10,000 variations of SPEED NUT brand fasteners. From this unlimited selection come many saving opportunities for you. Ask your Tinnerman representative to arrange for a free FASTENING ANALYSIS of your product. An engineering service that may produce similar savings for you.

You'll find Tinnerman under Fasteners in your SWEET's Product Design File and in the "Yellow Pages." *Tinnerman Products, Inc., Dept. 12, Box 6688, Cleveland 1, Ohio.*

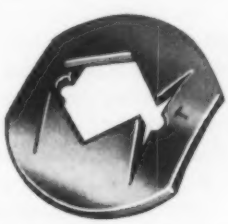
TINNERMAN
Speed Nuts®
Look for the Tinnerman "T"

OTHER T-MARKED SPECIALS



SPECIAL "J" SPEED NUT cuts production time in half for a major gas range manufacturer. Simplified right-angle panel or brace attachments for a variety of appliance, cabinet, and instrument applications. Live-spring tension means a vibration-proof grip.

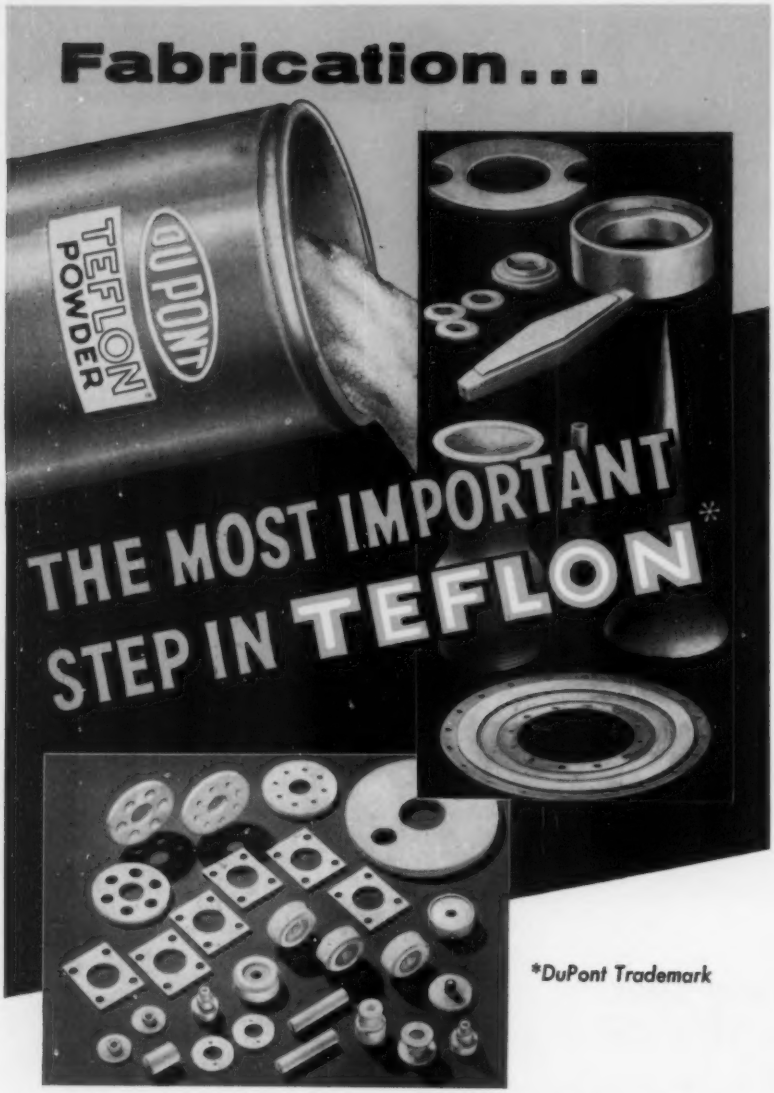
SNAP-IN FIXTURE FASTENER developed specially for Imperial Lighting Products Co., trimmed 80% off lighting fixture assembly time. Once fastened to the ceramic socket, this unique SPEED NUT snaps quickly into the fixture base...replaces three parts.



PUSH-ON SPEED NUT anchors latching bars on steel desks, reduces material and assembly costs by 50%. Push-on SPEED NUTS can be attached on studs, rivets, or tubing in a split second, and eliminates need for threaded parts . . . saves time and money.

CANADA: Dominion Fasteners Ltd., Hamilton, Ontario. GREAT BRITAIN: Simmonds Aerocessories Ltd., Treforest, Wales. FRANCE: Simmonds S.A., 3 rue Salomon de Rothschild, Suresnes (Seine). GERMANY: Mecano Simmonds GMBH, Heidelberg.

CIRCLE 95 ON READER SERVICE CARD 95



For instance, Crane Packing Company's new Teflon products plant was especially designed to obtain the highest quality fabrication of this material and includes the very latest in extruding, molding, curing and machining equipment. In critical areas, air is filtered to eliminate impurities, and climate is scientifically controlled to maintain proper density piece after piece. Result: *parts and components that retain all of Teflon's outstanding electrical, mechanical, anti-corrosive, heat-resistant and other properties.*

Whether *you* get this quality in your Teflon parts and components depends on your selection of a fabricator. Since the choice is yours, why not choose the best?

Contact us about your requirements. Request Bulletin T-110.

Crane Packing Company, 6445 Oakton Street, Morton Grove Ill. (Chicago Suburb).
In Canada: Crane Packing Company, Ltd., Hamilton, Ont,

CRANE PACKING COMPANY

tivity, 1 milliv. Measures 19 x 5¼ x 14 in., weighs 28 lb and can be rack- or bench-mounted. **Cubic Corp, San Diego 11, Calif.**

Circle 322 on Reader Service Card

Miniature dc relay . . .

occupies less than ½ cu in. of space when unenclosed. Available unenclosed or in one of three dust-tight enclosures with octal plug and solder hook terminal arrangements. SPDT or DPDT contacts are rated 1 amp resistive, 0.6 amp inductive at 26.5 v dc or 115 v ac. Nominal pull-in power is 0.75 w for SPDT unit and 1 w for DPDT unit. Temperature range (when specified) is —67 to 185 F and vibration (when specified), 10 g, 10-55 cps at 0.06 in. excursion. Unenclosed model measures ⅞ x ⅞ x ⅝ in. and weighs 11 grams. **Elgin Advance Relays, Electronics Div, 2435 N Naomi St, Burbank, Calif.**

Circle 323 on Reader Service Card

Low-pressure transducer . . .

is a 2-oz unit that operates in the range of 0-5 to 0-350 psi absolute, gage or differential. Standard models are rated —65 to 165 F; special units are obtainable up to 300 F. Resistance is from 200 to 10,000 ohms ±5%; linearity, within 0.75% of full scale; repeatability, within 0.5% of full scale; power rating, 0.25 w max at 70 F; and accuracy under vibration, within 1.5% max at 65 g's and 20 to 2000 cps. Standard models priced at $400 in quantities of 1 to 10. Delivery in 45 days. **Edcliff Instruments, 1711 S Mountain Ave, Monrovia, Calif.**

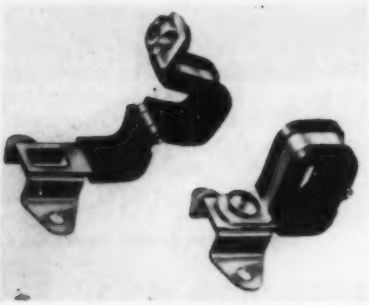
Circle 324 on Reader Service Card

Photoelectric counters, control systems . . .

have power-type photocells that directly activate sensitive relays, eliminating need for amplification. Registering up to 700 counts per min., the 115-v ac counter is operated directly by the sensitive relay. Its min "light-off" and "light-on" times are 30 millisec. Control system actuates auxiliary equipment through set of in-

ternally-mounted relays. Can be adjusted to extend hold-in time of relay from 40 millisec to 1 sec after light beam is restored, enabling control to act as a jam detector in applications requiring 1 sec or less timing for elimination of two pulses from an object with protruding parts. Both systems operate on line voltage of 105-125 v, 60 c, under max ambient temperature of 130 F. Electronic Controls Div, Veeder-Root Inc, Danvers, Mass.

Circle 325 on Reader Service Card



square and rectangular fasteners . . .

have built-in hinges and fast-acting key nuts for securing the clamps and allowing any degree of mechanical take-up. Can be attached permanently and do not have to be removed from original installation in open position. Once installed, fasteners can be opened or closed indefinitely without fatigue on metal. All components are captive. TA Mfg Corp, 4607 Alger St, Los Angeles 39.

Circle 326 on Reader Service Card

Magnetic reed switch . . .

measuring 0.095 in. in dia, makes possible use of miniature relays and cross-points in printed circuit boards or modules based on a 0.1-in. center. Said to last for at least three million operations at max rating and, except for resonant frequency, meets specifications of Signal Corps Technical Requirement SCL-7563. Glass length is $\frac{7}{8}$ in. and over-all length, $2\frac{1}{4}$ in. Priced at $3 each. Gordos Corp, 250 Glenwood Ave, Bloomfield, NJ.

Circle 327 on Reader Service Card

Temperature probe . . .

measure gases at velocities of 100 to 2000 ft per sec and temperatures up to 500 F. Thermocouple element—coiled to expose max surface to gas—is available in standard iron-constantan, copper-constantan and chromel-alumel wires. Bleed slot area is varied to give max accuracy at mean flow velocity in which probe is to be used. United Sensor & Control Corp, PO Box 149, Glastonbury, Conn.

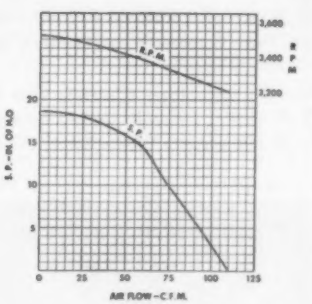
Circle 328 on Reader Service Card

continued on page 98

the pressure's on for '61

MULTI-STAGE BLOWER

60 cps or 400 cps
1Φ or 3Φ
To 440 Volts
10" O.D. by lengths up to 14"
Ambient Range: —55° + 85° C
Commercial or Military



MULTISTAGE BLOWER
60 cps — 6 Stages

When engineering specifications require continuous duty and quiet long life, Air Marine offers multistage blowers for low volume, higher pressure applications to 1 psi with air delivery to 100 CFM. Featured is long life with low noise. Where high pressure is required or on such vacuum applications as tape retention, the Air-Marine multistage blowers are the efficient answer.

Our field engineers will gladly assist you in the selection and application of motors, blowers or fans.

Air Marine motors, blowers and fans have been designed and tested to meet the specifications of both the military and industry.

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STANDARD

floating disc

single and double clutches or brakes

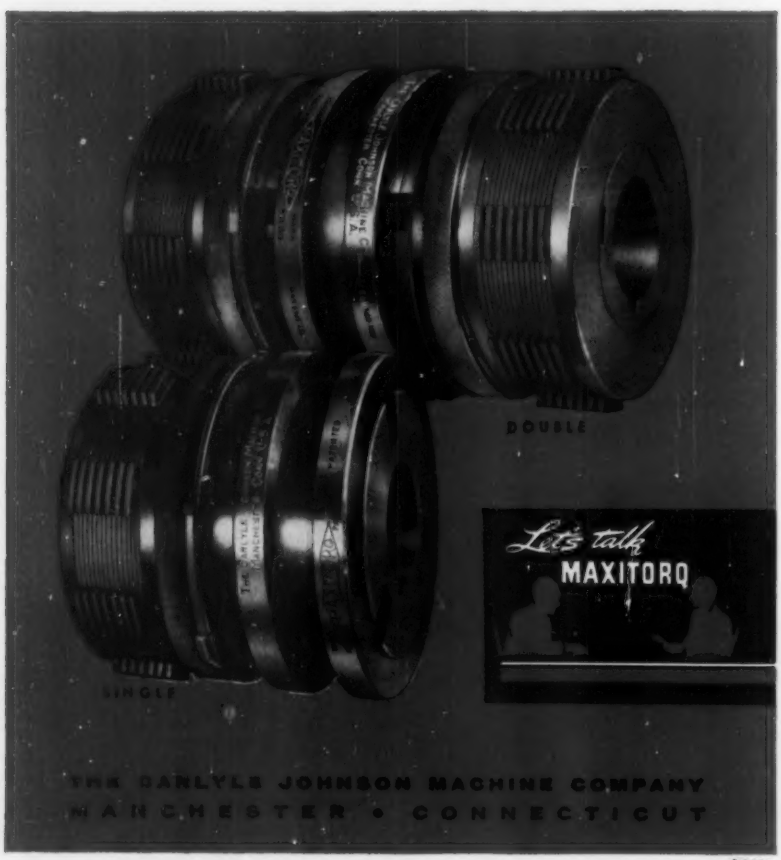
DESIGN PRINCIPLES OF THE 3 BASIC TYPES

The Maxitorq Clutch is completely assembled on the clutch body and shipped ready to slip onto a shaft. Separator springs . . . an outstanding feature . . . assure the advantages of truly floating discs. Used between each pair of inner discs, they spread them endways with an accordian action so that light can be seen between all discs when the clutch is in neutral. The floating disc feature makes certain that there's no drag . . . no abrasion . . . and consequently no heat when the clutch is in neutral.

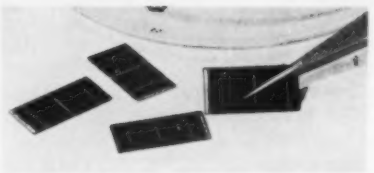
A locking plate on the disc end of each clutch (two on the double types) locks all discs against tension developed by the separator springs. Manual adjustment is made by raising the lock spring, then turning the adjusting ring to give the desired shifting pressure.

Note that assembly adjustment and take-apart are all manual . . . no tools required.

Standard Maxitorq Clutches are available in single and double types, wet or dry . . . also in pulley and cut-off coupling types. Capacities to 15 h.p. at 100 r.p.m. Write Dept. PE for bulletin today.



1CJ60



"Gridded" silicon solar cell

is made with a number of secondary collector strips protruding from main or primary strip, allowing better collection of current from active cell area. Collectors, in effect, form a grid network over active area of the light-converting semiconductor device. Cell output power is said to be 20% higher than non-gridded cells under given light and load conditions. From stock at $2 to $6 in quantities of 1 to 99. **International Rectifier Corp, 1521 E Grand Ave, El Segundo, Calif.**

Circle 329 on Reader Service Card

High-speed digital readout . . .

both receives and transmits, and is designed as a building block for automation, machine production and other systems requirements. Registers up to 2000 counts per min at rated voltage—said to be twice the speed of other units. Operating pulse is 60% "on" time (min of 18 millisec recommended) and 40% "off" time (min of 12 millisec recommended). Remote resetting by electrical pulse is provided for. Operating coil is rated at 6 w and reset coil at 32 w. Recommended readout circuit capacity is 1 amp ac or dc. Equipped for panel mount with either four or six figures. Enclosure measures approx 3 x 3 x 3 in. (electric reset increases depth by 2 in.); figures (white on black background), each $\frac{3}{16}$ in. **Vedder Root Inc, 70 Sargeant St, Hartford 2, Conn.**

Circle 330 on Reader Service Card

Solderless terminating device

can be used as a multi-pin connector, as a terminal block or as both at the same time. Electrical connection between two wires is made by crimping a female tab terminal on each end of the wires, and, in turn, plugging the terminals on opposite ends of a male pin located on connector block. Houses up to 300 male pins and is similar in appearance to tree-type solder terminal blocks. Said to result in a number of cost reductions. Components are $\frac{1}{4}$th to $\frac{1}{10}$th the cost of high-quality multi-pin connectors and only slightly more than for solder-type terminal blocks. Also eliminates on-the-job wiring and takes less space for a given number of connectors than solder units. **Thomas & Betts Co Inc, 36 Butler St, Elizabeth, NJ.**

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DURA SEAL

THE ENGINEERED MECHANICAL SEAL

. . . spells out the answer to your sealing problems

D ecreases maintenance expense

U naffected by corrosives

R otates with the shaft

A djusts itself automatically

S eals abrasive liquids

E liminates scoring of shafts

A daptable to standard stuffing boxes

L essens power costs

For free engineering counsel on your sealing problems . . . write

The PERFECT SEAL TRADE MARK

DURAMETALLIC CORPORATION
KALAMAZOO, MICHIGAN

Trimming potentiometer . . . has printed circuit connections and tiny height-off-board dimension of 0.195 in. These, coupled with unit's ½-in. sq shape, are said to be advantageous in stacking printed circuit board together into various modular assemblies. Trimmer's resistance values run from 10 ohms to 50 kilohms over operating temperature range of from −67 to 392 F, and its resolution at 50 kilohms is 0.086%. These values result from use of a circular mandrel which permits longer resistance winding and 30% more turns for one complete sweep of the wiper. Power rating is 1 w up to 122 F, derating to 0 up to 392 F in still air. From stock. **Daystrom Inc, Potentiometer Div, Archbald, Penna.**

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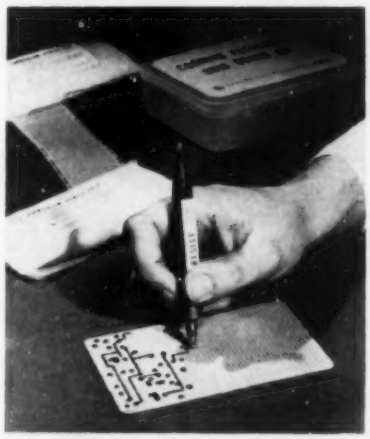


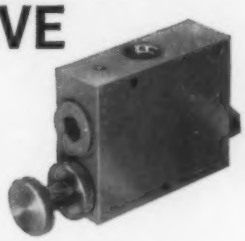
Prototype printed circuitry kit contains all necessary materials to produce a printed circuit on glass-ceramic substrate in 15 min. Each kit includes two 3 x 5 in. copper-clad, glass-ceramic grid boards; grid paper for practice layouts; liquid etching resist for board circuit layout; vinyl resist tape; two bags of ammonium persulfate crystals for making etching solution, etc. Plastic box serves as etching pan. From stock at $8.95 for kits containing two boards and $1.95 for kits without boards. **Corning Glass Works, Corning, NY.**

Circle 333 on Reader Service Card

Gear-train layout kit . . . contains 8 x 10 in. layout board marked with ⅛-sq-in. grids; 10 center pins color-coded for component identification; and 100 transparent gear disks. Allows gear-train layouts to be made without erasing and redrawing or using paper cutouts. In most cases, layout drawing can be eliminated by transferring gear location dimension from grid board directly to an assembly drawing. From stock in 48, 64 and 96 diametrical pitch at $6.50 each. **Advanced Designs Inc, Vienna, Va.**

Circle 334 on Reader Service Card

New, compact PRESSURE CONTROL VALVE



for low-pressure or high-pressure circuits

The Dynex pilot-operated, hydraulically balanced pressure control valve is designed for simplified application and low-cost installation. Functions efficiently at high or low pressures. Withstands severe shock loads. This new design features excellent characteristics of low override, low override with increasing volume, and quick reseating.

The same basic configuration adapts for service as a relief, sequence or unloading valve. Suitable for pressures to 8,000 psi and for flows to 30 gpm, with a liberal safety factor. To determine which design fits your current project, check the chart below. Write Dynex for data and application assistance.

Select the configuration that suits your needs

Typical Model Number ▶ VR-6120-12-00

FUNCTION
R-relief
S-sequence
U-unloading

MAX. PRESSURE
1 - 1,000 psi
3 - 3,000 psi
6 - 6,000 psi

BODY DESIGN
1 - standard

GPM
10 20 30

DESIGN NO.

DRAIN
1 - internal
2 - external

ADJUSTMENT TYPE
1 - concealed
2 - exposed
3 - knurled knob

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For your copy of the Stratos Engineering Manual and Data Sheets illustrated above, write

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DESIGN LITERATURE

Analysis and Design of Mechanisms

DEANE LENT. Prentice-Hall Inc, Englewood Cliffs, NJ. 9¼ x 6¼, 328 pp. $9.35.

This book is written expressly for those who are beginning the study of mechanisms as a steppingstone to machine design. The approach is elementary, developing the fundamentals of displacement, velocity, and acceleration and applying these to both the analysis and design of mechanisms. The author takes nothing for granted, always showing the reader "how" and telling him "why."

Fundamental principles are stressed throughout, providing a thorough grounding in basic methods and techniques having universal application. Methods of analysis are developed which may be applied to all mechanisms, and which the reader will use to solve new or unfamiliar problems as they arise. There is minimal use of mathematics; graphics is used extensively wherever calculations would be slow or too complex.

Successful Managerial Control by Ratio-analysis

SPENCER A TUCKER. McGraw-Hill Book Co Inc, 330 W 42nd St, NY 36. 9¼ x 6¼, 434 pp. $11.

This text describes how to develop and apply the concept and techniques of ratio-analysis in a wide variety of industrial situations for more effective management control. The system of control—called "MC" by the author—reduces company data and statistics to significant mathematical ratios, and interrelates their movements to provide managers with the necessary tools for evaluation, decision-making, remedial action, and long-range planning.

The book describes how a manager can cope with a myriad of facts, events, and changes constantly generated normally in all areas of business activity. Survival and growth, the author points out, demand from management fast, perspectively weighted action and control over every company area—during the facts, not after. MC quickly defines the optimum economic environment, and by means of ratios, maintains a continuous reading of the pulse of any business operation. Translated into graphs and curves, these values can be easily read, and acted upon objectively, thus eliminating needless details and freeing managers for work in more vital and productive areas.

Shock and Structural Response

MILLARD V BARTON. American Society of Mechanical Engineers, 29 W 39th St, NY 18. 8½ x 11, 79 pp. $4.50.

This compilation includes five papers presented at a colloquium on shock and structural response at the Annual Meeting of the ASME, November 30, 1960.

The determination of the responses of systems to shock as well as the characteristics and measurement of the shock itself have been subjects of extensive investigations for many years. This material reflects the wide range of subjects and methods used in the rapidly developing field of shock and structural response. As such, several different viewpoints are expressed or implied which illustrate the scope of the subject and provide some specific useful information without attempting to include extensive handbook material and procedures.

The contents include: "Shock-loading and Response Spectra," Y C Fung; "Measurement of Shock," Irwin Vigness; "Concepts in Shock-testing Equipment," Charles E. Crede; "Response of Structural Systems to Ground Shock," Dana Young; "Ground Shock and Missile Response," Millard V Barton.

Other Books of Interest

Introduction to Mathematical Probability

J V Uspensky. McGraw-Hill Book Co Inc, 330 W 42nd St, NY 36. 5½ x 8, 411 pp. $2.95.

Paperback edition of original edition copyrighted in 1937.

AWS Definitions—Welding and Cutting

American Welding Society, 33 W 39th St, NY 18. 6 x 9, 59 pp. $2.

Airborne Radar

D J Povejsil, R S Raven, P Waterman. D Van-Nostrand Co Inc, 120 Alexander St, Princeton, NJ. 6¼ x 9¼, 823 pp. $17.50

Describes basic radar technology and application to weapons-system design.

continued on page 103

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Equipment designers now have a wider temperature range . . . from 150° to 700°F . . . in which to design and operate gas-fired equipment and appliances . . . with full control at any point in the temperature range.

The perfection of a combination snap and throttle thermostat, Robertshaw's **FLAME MASTER FD** gives flat-line control from 300° up . . . and very modest fluctuations in the low range, with full control down to 150°. Even the *minimum* flame setting is under thermostatic control.

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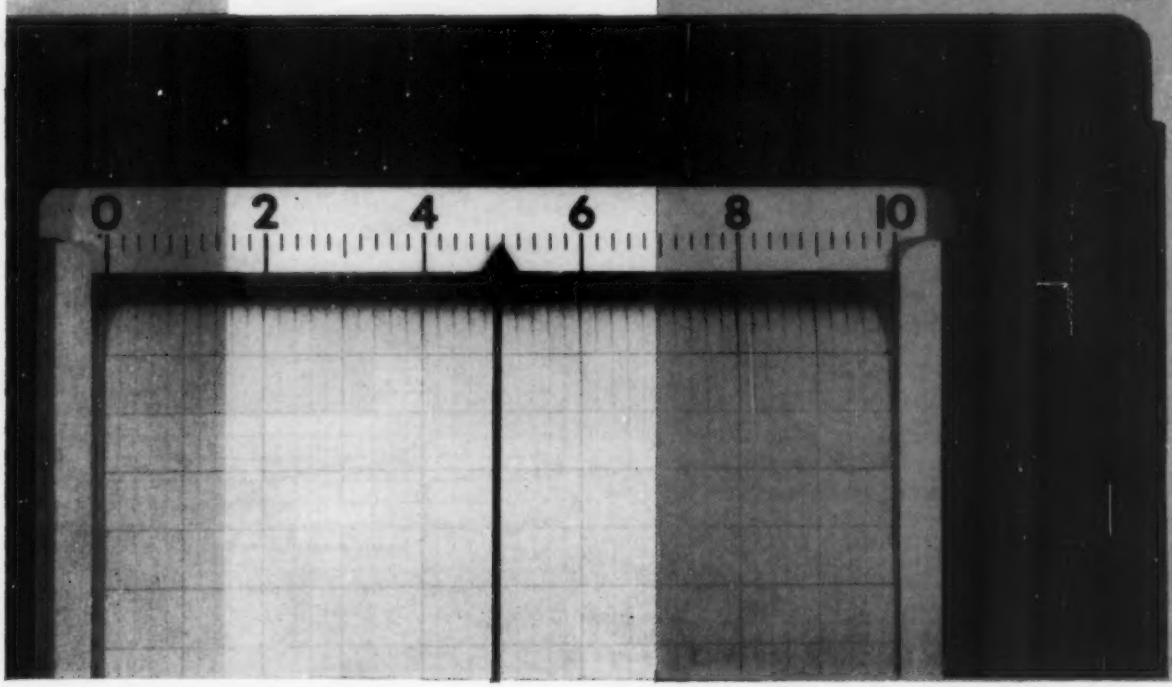

Photo of Speedo-Max Recorder courtesy Leeds & Northrup Company

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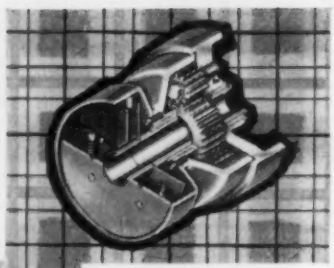
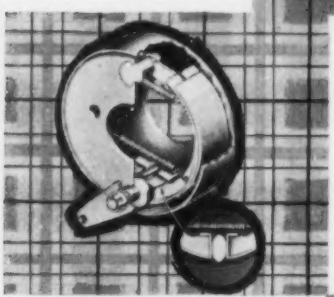
Packaged Reversible Transmission for 1½ to 5 hp. Only 4" long, less than 5" dia., it mounts on engine or motor shaft extension or may be used as auxiliary drive. Eliminates gear shifting levers, belt tighteners, includes F-M centrifugal clutch.





Automatic Centrifugal Clutch produces up to 50 lb. ft. at 3600 rpm. Three standard types, extremely compact, adapt easily to pulleys, sprockets, gear or coupling drives. Provides Free-wheeling and Overload-protection. Adjusts to engage smoothly at desired speed as load accelerates.

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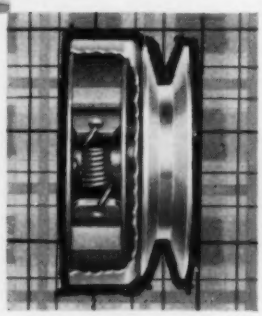

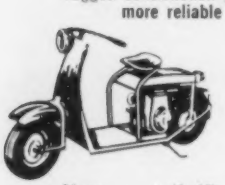

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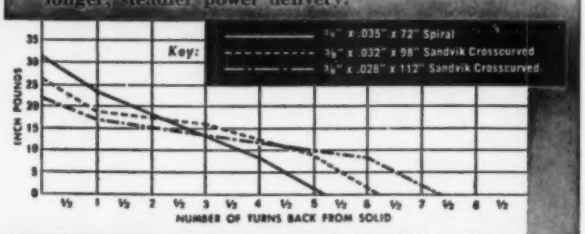
Sandvik crosscurved springs store energy both *along* their length and *across* their width. This dual capacity is produced by winding the spring against both its tempered spiral length and against its "*crosscurve*," a special convex curvature of the strip width. As shown in the chart, this process makes possible the use of longer, thinner springs and results in longer, steadier power delivery.



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The Theory of Equations—2 Vols

W S Burnside, A W Panton. Dover Publications Inc, 180 Varick, NY 14. 5¼ x 8, Vol. 1 286 pp, $1.85; Vol. 2 318 pp, $1.85; set $3.70.

Unaltered paperback edition of last (seventh) revised edition originally published in 1928.

Introduction to Electronics

R J Hughes, P Pipe. Doubleday & Co Inc, Garden City, NY. 6 x 8½, 421 pp. $3.95.

One of the Tutortext series of books for self-instruction. Instructs the reader, questions him and, if mistake is made, explains it.

Small Plant Management

W A MacCrehan, Editor. McGraw-Hill Book Co Inc, 330 W 42nd St, NY 36. 6¼ x 9¼, 563 pp. $10.50.

ABSTRACTS FROM THE LITERATURE

Weatherability of Linear Polyethylene

From this study, it may be concluded that for maximum outdoor serviceability with respect to retention of elongation, tensile-strength and melt-index properties of a particular molded item, certain precautions in specifying resin formulations and design detail are required. These are described in detail.

"Status of Investigations for Improving the Weatherability of Linear Polyethylene and Copolymers," by C. Gottfried and M. J. Dutzer, Celanese Plastics Co. Presented at the 17th Annual Technical Conference, SPE, 65 Prospect St, Stamford, Conn.

Threshold Values for Stress Corrosion

This study concludes that stress-corrosion problems cannot be entirely eliminated at this time through control of specific parmeters to established threshold values. Instead such approaches as following are proposed: use of more resistant materials; design changes, reduction of corrosivity of environment, reduction of effective stress, use of protective layer. Special study is given to behavior of AISI 410 steel.

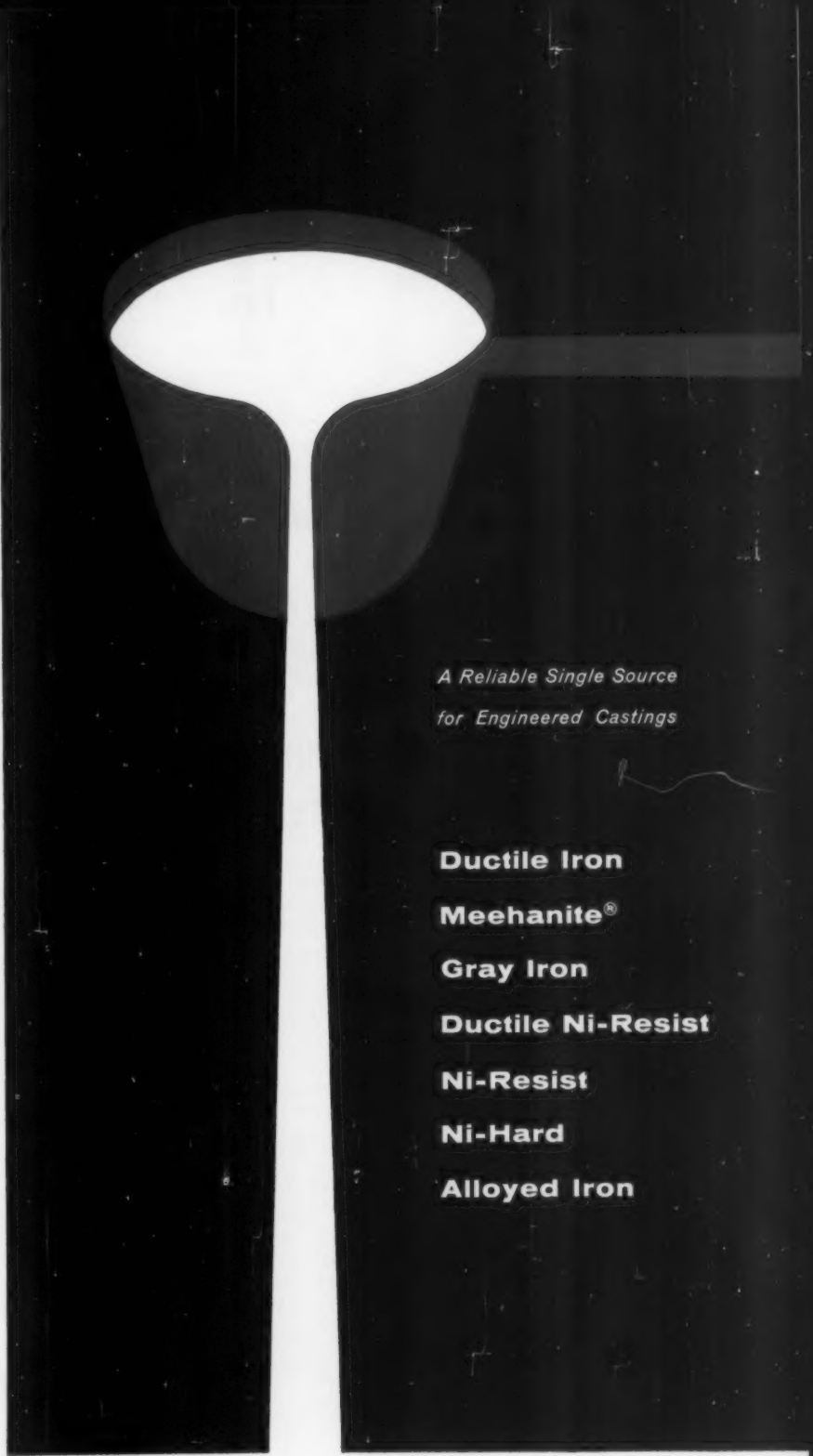
"Practicality of Establishing Threshold Values to Eliminate Stress Corrosion Failures in Metals and Alloys," Henry Suss, General Electric Co. Corrosion, Feb, '61. 1061 M & M Building, Houston 2, Texas.

Relay-contact Failures

The most prevalent factors which cause contact failure are:

• Contact contamination, which results in: excess contact resistance; electrical contact wear; mechanical

continued on page 104



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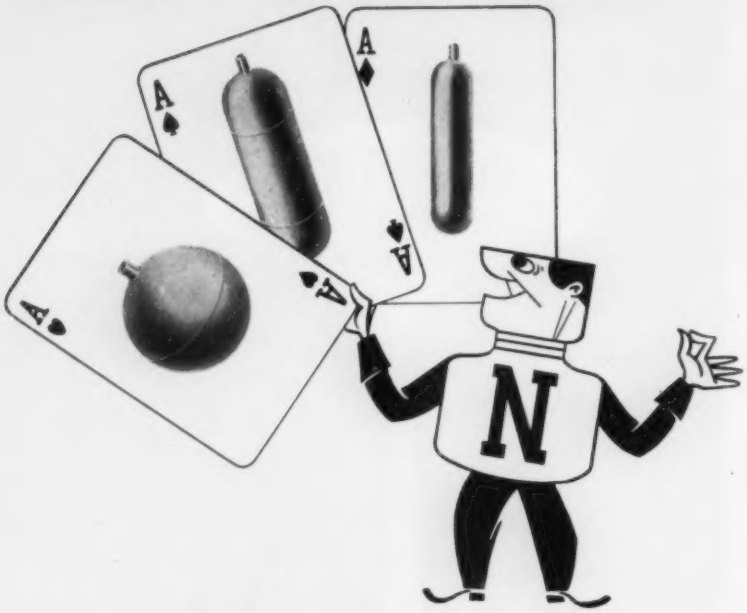
CIRCLE 103 ON READER SERVICE CARD

Nicholson Welded Floats . . .



'aces' for buoyancy mediums, fluid chambers, pressure vessels

Long, trouble-free service! You can count on that, for sure, with Nicholson floats, for working pressures up to 2500 lbs. They're precision-welded to stand up to the pressure or corrosive conditions for which they're specified. Available in spherical, cylindrical or elliptical shapes . . . and from 2" to 14" diameter sizes. Float halves are die-formed, spun, laminated or electro-deposited. Walls are, therefore, uniformly thick. Annealed to avoid cracking. Butt-welded seams. *Steel Floats:* chromium, cadmium, copper plated. Also unplated, with sandblast or pickled finish. *Stainless Steel and Monel floats:* rough buffed, polished or with smooth, highly-finished welds.

This Coupon Brings You Informative Bulletin On Floats

Bulletin 753 contains facts on steel, stainless steel and monel floats, information on float connections, tables showing weight, buoyancy and collapsing pressure for spherical floats for all gauges . . . also volume and buoyancy data. Fill in and mail this coupon for your copy.

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contact wear; vaporization of contacts, which in turn results in loss or transfer of contact material.

• Contact welding, which is often caused by: insufficient contact gap, excessive contact pressure, and overtravel; contact overload.

• Relaxation of contact arms due to mechanical fatigue or loss of tension due to internal temperature resulting from coil operation and contact loading.

"Relay-contact Failures," Leon D. Carr, Sperry Gyroscope Co. Published in NARM Relay Symposium Papers at 8th Annual Relay Symposium at Stillwater, Okla.

CATALOGS AND BULLETINS

To obtain copies of literature described below, circle corresponding number on postcard inside back cover. For those catalogs and bulletins available only when requested on company letterhead, see page 115.

PRECISION SWITCHES—Catalog 104, 20 pp. Illustrates, describes performance and gives electrical ratings of over 200 items, including miniature, special purpose, lighted pushbutton, toggle, limit, proximity and mercury switches, as well as electronic switch-circuit assemblies. Micro Switch Div, Minneapolis-Honeywell Regulator Co, Freeport, Ill.

Circle 350 on Reader Service Card

SPROCKETS—Catalog 2, 8 pp. Tabulates physical data on stock sprockets in five chain sizes, varying in teeth from 11 to 112. Data includes number of teeth, OD, bore size in inches, max rebore, hub dia, length through bore, approx weight and price. Three styles are treated—those without hubs, with hubs and those with standard keyway and setscrews. Dayton Rogers Mfg Co, 2824 13th Ave S, Minneapolis 7.

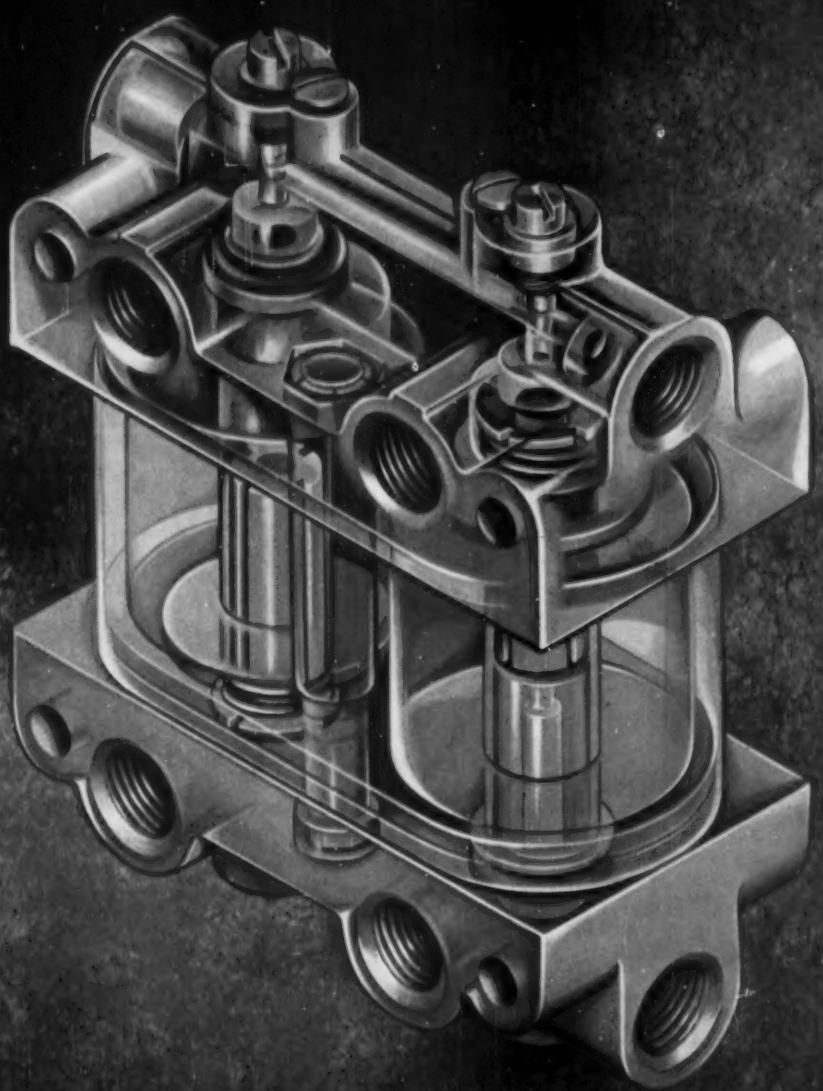
Circle 351 on Reader Service Card

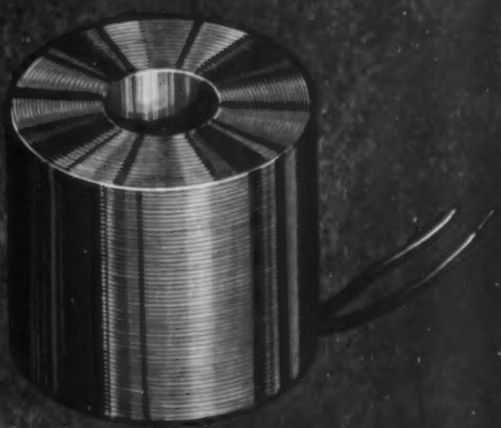
ACRYLONITRILE—Booklet, 25 pp. Discusses physical and toxicological properties, reactions, applications, specification limits, test methods, storage, handling and shipping. Charts illustrate material's performance. Union Carbide Chemicals Co, Div Union Carbide Corp, 270 Park Ave, New York 17.

Circle 352 on Reader Service Card

PRESSURE CLAMPS AND HOSE FITTINGS—Catalog B-5, 24 pp. Presents specifications and prices of product line, including preformed clamps, hose nipples and mender, swivel adapter unions and big hole couplers, listing each with BS-21 (British Standard Pipe Threads) and NPT numbers. Instructions for applying many

continued on page 107





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Solenoid Valves

assure precise cylinder control

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- **Precise flow control**—by adjustable metering
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- **Wired from front or rear**—housing easily reversed
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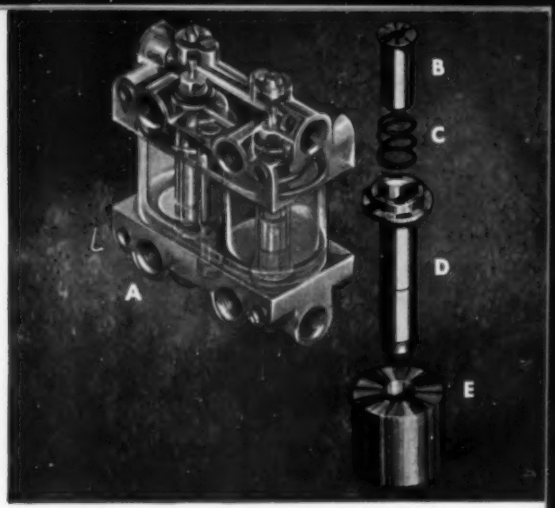
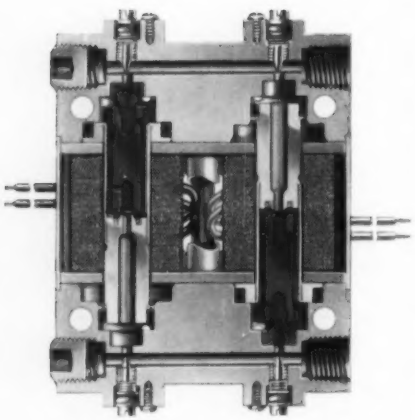


A. Transparent view of 4-way solenoid valve B. Plunger C. Plunger return spring D. Sleeve E. Coil

SKINNER four-way solenoid valves available in three basic types



The Skinner V9 solenoid valve is two 3-way valves in one compact housing. Both valves may be independently controlled and metered to provide accurate, dependable control of single- or double-acting cylinders, or larger pilot-operated valves.

V9 types are available without adjustable flow and with metering at both exhaust ports, both inlet ports or full metering of all ports.

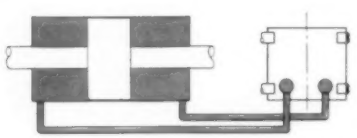
• • •

For complete information, contact a Skinner Distributor listed in the Yellow Pages or write us at the address below.

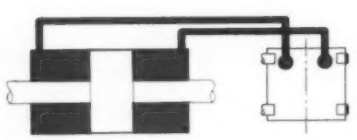
V9 SERIES SPECIFICATIONS

Media—air, hydraulic oils, inert gases
Orifice Diameter—$\frac{3}{64}$", $\frac{1}{16}$", $\frac{3}{32}$", $\frac{1}{8}$"
Pipe Size—$\frac{1}{4}$" NPTF
Maximum Operating Pressure Differential—0 to 150 PSI (up to 225 PSI also available)
Temperature Range—minus 40°F. to plus 180°F.
C_v Factor—$\frac{3}{64}$" .052, $\frac{1}{16}$" .095, $\frac{3}{32}$" .156, $\frac{1}{8}$" .214
Mounting—$\frac{1}{4}$" through-bolt holes.

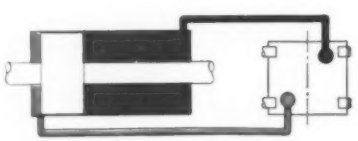
Normally closed—normally closed V933 valves with a neutral position. Generally applied on double-acting cylinders where the piston is in a neutral position without pressure when both coils are de-energized. This permits manual shifting of the piston without operating the valve.



Normally open—normally open V955 valves with a neutral position. Generally applied on double-acting cylinders where both sides of the piston are to be open to pressure when both coils are de-energized. Under certain conditions, the first operating stroke of double-acting cylinders will be smoother with this valve in use.



Normally closed—normally open V935 valves with no neutral position. Generally applied on double-acting cylinders where the piston is to be in retracted or extended position with pressure when both coils are de-energized. Wiring is simple—both coils are operated simultaneously and can be controlled by one single-pole, single-throw switch.



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of the products are sketched, and results of burst, tension, flex and constant-pressure tests are given. Band-It Co, 4779 Dahlia St, Denver 16.

Circle 353 on Reader Service Card

SPIRAL BEVEL GEARS—Catalog, 6 pp. Spells out specifications of standard design gears with ratios of 1:1, 2:1, 3:1, 3:2 and 4:3. Power ratings are treated in a listing of peripheral speeds and velocity factors. Perkins Machine & Gear Co, West Springfield, Mass.

Circle 354 on Reader Service Card

WELDED TUBING—Brochures 60B and 60C, 4 pp each. Former charts min and max wall thicknesses for various cold drawn tubing diameters and gives 11 standard analyses and 75 special materials in which this type tubing can be furnished. Latter offers similar data on bead-reduced tubing and lists its 86 available analyses. Illustrations in former include photomicrographs of weld zone. Western Pneumatic Tube Co, Kirkland, Wash.

Circle 355 on Reader Service Card

SQUARE TRIMMING POTENTIOMETERS—Catalog, 6 pp. Outlines complete specifications of 14 series, including resistance, power, operating temperature, resolution, load life at rating, torque, temperature coefficient, etc. Illustrations include power rating curve and cutaway showing "V" guide for eliminating backlash and resultant error. Potentiometer Div, Daystrom Inc, Archbald, Penna.

Circle 356 on Reader Service Card

INDUSTRIAL LAMINATES—Catalog L-CDL-514, 16 pp. Properties, tolerances, thickness ranges, characteristics and applications are presented for 39 grades of copper-clad, sheet, tube and rod laminates. General Electric Co, Laminated Products Dept, Section IS, Coshocton, Ohio.

Circle 357 on Reader Service Card

continued on page 109

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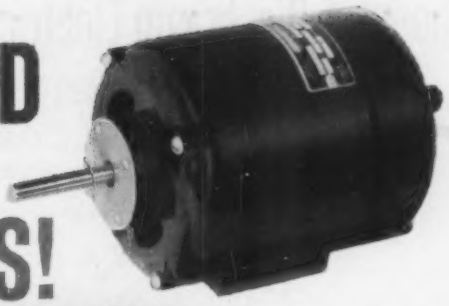

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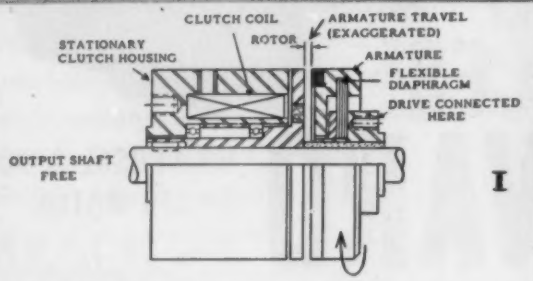
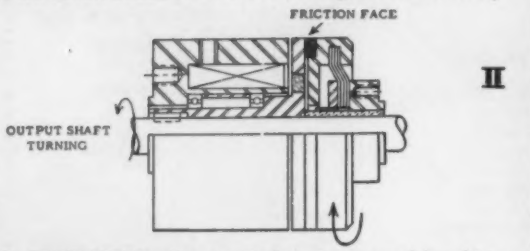


I. DE-ENERGIZED: Armature turning, shaft stationary



II. ENERGIZED: Output shaft being turned by drive through armature to rotor

Like most really sound engineering ideas the practicality and economy of electric clutches and brakes without the conventional sliding armature had to be proved in practice.

Now, a few short years after their introduction, Simplatrol electric clutches and brakes **have** proved that their design, based on a flexible diaphragm in the clutch's armature, does do a better job than armature plates sliding on splines, pins, or hubs.

Simplatrol's armature, a **one-piece** assembly, deflects to perform clutching or braking action. Wear is reduced to vanishing point since there are no sliding parts to contact each other; instant performance is achieved without slow release, or "hanging up."

This Simplatrol diaphragm principle ensures smoothness, quietness, and consistency.

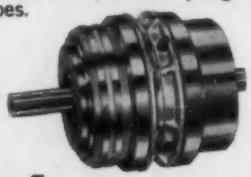
Compare the installed cost.

Simplicity carries through to the installation, reducing cost here as well. You simply slip one of the 2 or 3 major assemblies onto the shaft — that's all the assembling you do! No pins, no nuts, no washers, no springs to run up labor cost.

Machined parts in the clutches and brakes are of uniform quality. There's close built-in control of tolerances and finishes . . . and the assemblies are pre-burnished! All clutches include bearings, machined surfaces and bolt holes for direct mounting of your drive unit.

Simplatrol offers a complete range of diaphragm electric clutches from torque of 10 ounce inches to 470 pound feet in diameters from ⅞" to 12½". Styles include clutches, brakes, clutch-brakes, duplex clutches, and couplings in both rotary and fixed field types.

Ask Simplatrol's sales engineers to demonstrate to you specifically how the unique advantages of flexible diaphragm performance will benefit your operation.



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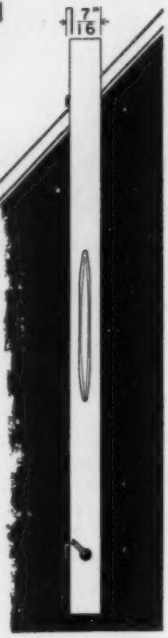

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ALUMINUM ALLOYS—Data file, 6 pp. Outlines data on 10 most used alloys, including applications, uses, strengths, thermal and electrical conductivity, density, specific gravity, melting range and manufacturing limits. Also includes tables on weights, tolerances, fabrication, available finishes, hardening properties and embossing designations. Fairmont Aluminum Co, Fairmont, W Va.

Circle 358 on Reader Service Card

SPRINGS AND SHOCK ABSORBERS—Handbook CH-1, 12 pp. Explains operation of springs, spring shock absorbers, time-delay shocks and dashpots that store energy by using limited compression of liquids at high pressures. Tabulates specifications of standard models and gives formulas for determining special size envelopes. Taylor Devices Inc, North Tonawanda, NY.

Circle 359 on Reader Service Card

REGULAR AND REINFORCED TEFLON PARTS—Brochure 9572, 4 pp. Compares electrical, physical, mechanical and chemical properties of regular Teflon and a reinforced fluorocarbon resin, which is said to have increased mechanical strength and wear resistance. Illustrates basic shapes and typical fabricated parts, including O-rings, bearings, bushings, ball bearing retainers, etc. Plastics Div, Dixon Corp, Bristol, RI.

Circle 360 on Reader Service Card

ARC WELDING—Bulletin 7000.7, 40 pp. Discusses correct electrode selection for every type of welding application and lists arc characteristics, welding procedures and physical properties of each electrode, including stainless steel, cast iron and hard-surfacing types. Also traces performance and construction features of arc welders, including electric and gas engine driven

continued on page 111

"Did I leave my slide rule here when I came back after my pencil?"

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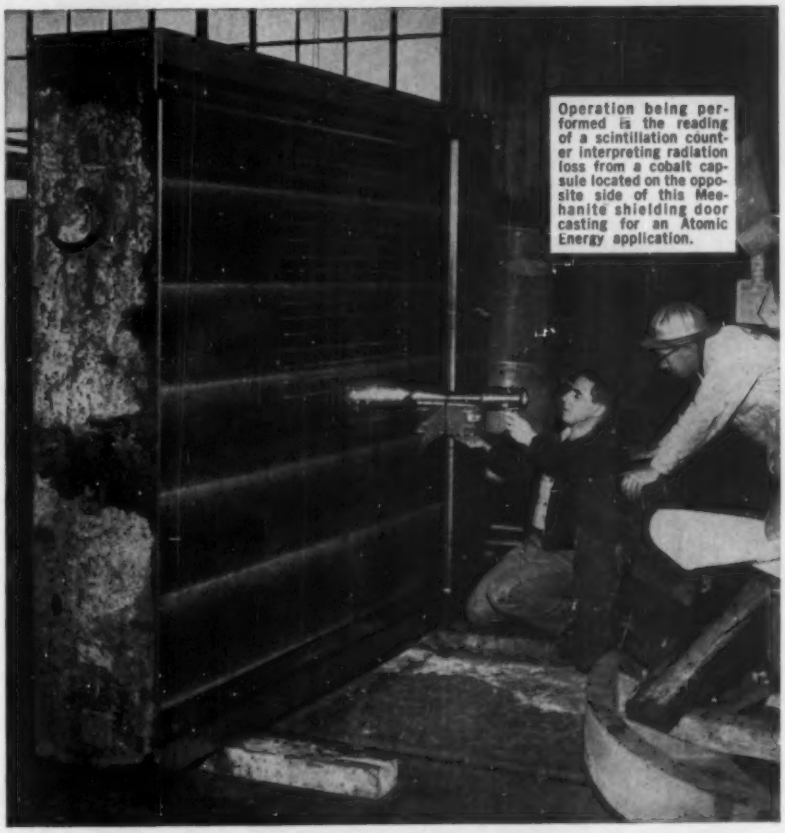
Operation being performed is the reading of a scintillation counter interpreting radiation loss from a cobalt capsule located on the opposite side of this Meehanite shielding door casting for an Atomic Energy application.

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In massive castings of this type which have a slow cooling rate, there is a natural tendency towards a more open structure with a corresponding loss in strength. However, in Meehanite castings the effect of "mass influence" is minimized through the use of constitutional carbide controls which are exclusive to the Meehanite Process. Breakdown of structure due to slow cooling is avoided by providing a definite degree of undercooling of the graphite to the melt.

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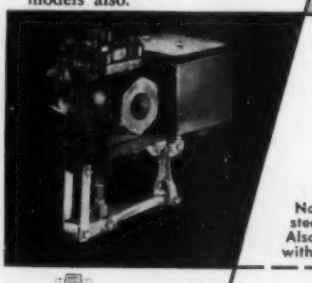
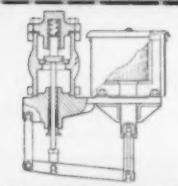
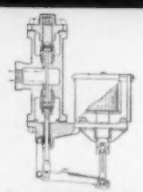
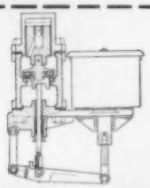




Normally closed service, stainless steel valve and seat. Sizes ⅜"-3". Also for normally open service, and with Jenkins Disc.



3-way valve. Stainless steel valves and seats. Sizes ½"-1½".



Dashpot construction, cushions closing to avoid water hammer. Jenkins Disc. Sizes ¾"-2".

Write for Bulletin "V"

THE JOHNSON CORPORATION
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CIRCLE 211 ON READER SERVICE CARD

CIRCLE 110 ON READER SERVICE CARD

generators, and transformer and transformer rectifier designs. Lincoln Electric Co, 22801 St Clair Ave, Cleveland 17.

Circle 361 on Reader Service Card

ALUMINUM BAR STOCK—Brochure 98-161-5, 8 pp. Tables carry weights, precalculated cleanup and machining allowances, wall thicknesses, lengths and mechanical properties. Advantages of deep-drawn hollow stock over solid bar stock for machining applications are discussed. Harvey Aluminum, 19200 S Western Ave, Torrance, Calif.

Circle 362 on Reader Service Card

STEEL TUBING—Catalog CS-61, 8 pp. Supplies characteristics, applications, size ranges and tolerances of both seamless and electric-welded tubing. Also discusses fabricating and forging into finished or semifinished tubular parts. Ohio Seamless Tube Div, Copperweld Steel Co, Shelby, Ohio.

Circle 363 on Reader Service Card

MOBILE EQUIPMENT VALVES—Bulletin M-5112, 8 pp. Describes and illustrates design features of directional control units, available in any number of sections up to 10. Sketches show basic spool designs, and curves provide pressure-drop data. Vickers Inc, Div of Sperry Rand Corp, Detroit 32.

Circle 364 on Reader Service Card

REGENERATIVE TURBINE PUMPS—Catalog sections 101 and C101, 12 and 36 pp. Former contains selection, performance and mechanical data, plus installation dimensions of three end-mounted designs. Includes capacity curve, total dynamic head tabulations, exploded views and cutaways. Latter has performance curves of pumps listed in former publication. Roy E. Roth Co, Turbine Pump Div, Rock Island, Ill.

Circle 365 on Reader Service Card

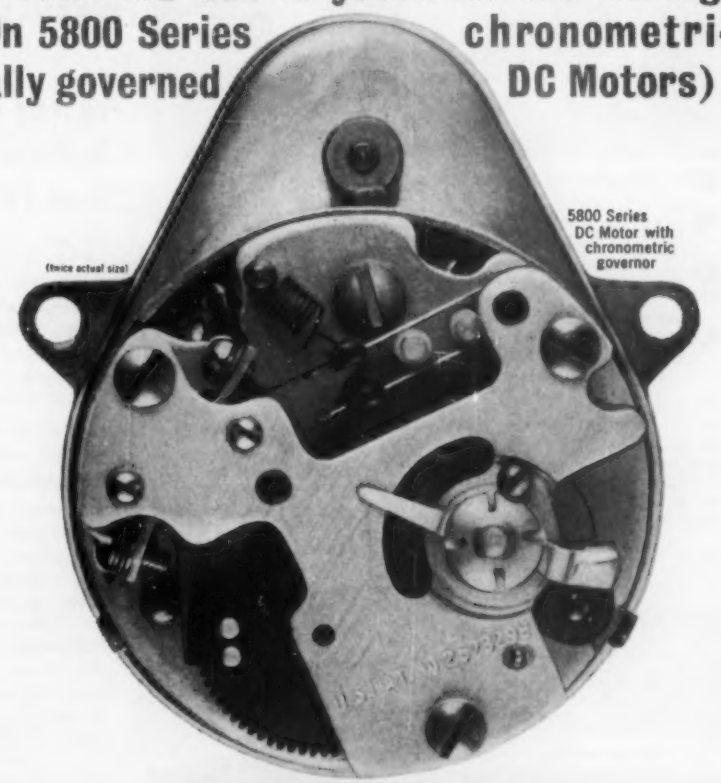
CONTROL AND TORQUE SYNCHROS—Data sheet CS/TS-6-23-1, 2 pp. Cover size 23, 60-c units for servo applications. More than 25 characteristics are listed for transformers, transmitters, and differential and receiver transmitters. Schmatics, spline data, wiring diagrams and terminal designations are included. Vernitron Corp, 125 Old Country Rd, Carle Place, LI, NY.

Circle 366 on Reader Service Card

PIEZOELECTRICITY—Booklet, 16 pp. Outlines and compares performance characteristics of major jizeoelectric substances and discusses application of piezoelectricity in converting mechanical energy to electrical energy and the reverse. Also

continued on page 113

Who needs feedback? The patented chronometric governor of this standard DC Timing Motor is a tyrant. Without any other circuitry, it holds the motor output speed within ± 0.1% while driving charts, cams, contacts, actuators or other devices. It holds the rate even if output shaft load, line voltage, or ambient temperatures change. And that's just the standard model of this little gem. Custom variations can do even better, under special conditions. The A. W. Haydon Co. knows all about timers and timing. If you have a specific timing problem, you ought at least to have our literature. Bulletin MO 802 is yours for the asking. (On 5800 Series chronometrically governed DC Motors)



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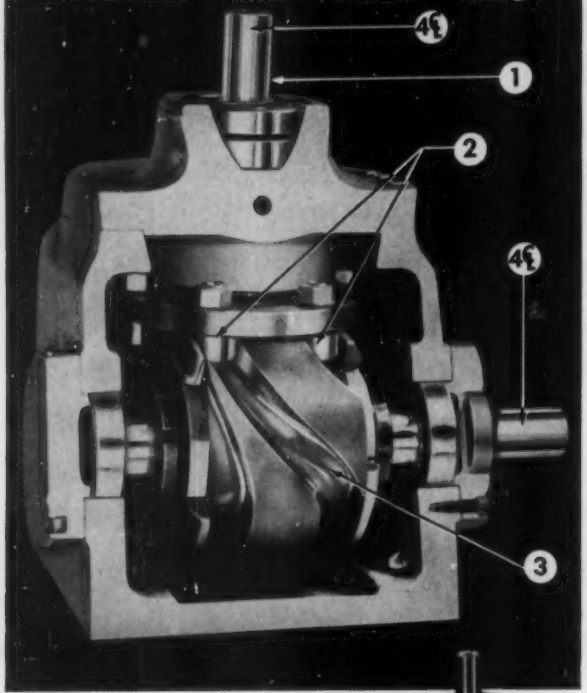

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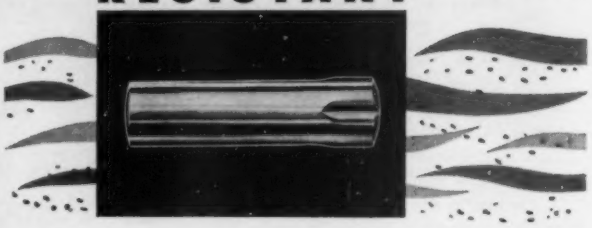

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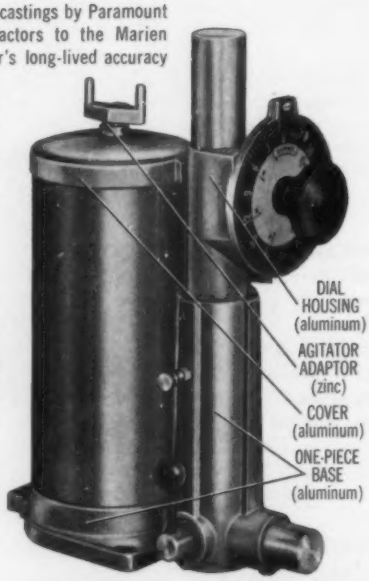

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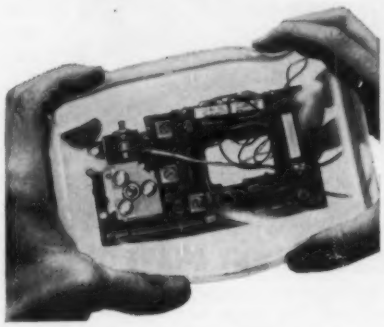

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DESIGN LITERATURE . . . . . continued

covers electromechanical properties and service temperature range of piezoelectric elements. Clevite Electronic Components, Bedford, Ohio.

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PNEUMATIC VALVE-POSITION TRANSMITTER—Bulletin 0285.20-1, 2 pp. Lists advantages, specifications and dimensions of unit for translating position of a valve or similar mechanism into a proportional pneumatic output pressure. Includes outline drawings. B-I-F Industries, PO Box 276, Providence 1, RI.

Circle 368 on Reader Service Card

GEARS AND RELATED PARTS—Folder, 4 pp. Contains photos and engineering data on 28 types of gears, gear heads, differentials, worms, clamps and black boxes. Instru-Lec Corp, 520 Homestead Ave, Mt Vernon, NY.

Circle 369 on Reader Service Card

MOTOR CONTROL—Bulletin 343, 4 pp. Diagrams and curves illustrate discussion of feedback servomechanism's operation. Two graphs show effect of unit on welding positioner under load. Sciaky Bros Inc, Dept L-30, 4915 W 67th St, Chicago 38.

Circle 370 on Reader Service Card

STRAIN-GAGE ACCELEROMETER—Bulletin 4203, 2 pp. Lists input, output, environmental and physical specifications. Includes dimensional drawings. Consolidated Electrodynamics Corp, 360 Sierra Madre Villa, Pasadena Calif.

Circle 371 on Reader Service Card

CIRCUIT MODULE - AMPLIFIER—Data sheet DPS, A8, 2 pp. Supplies specifications and application diagrams for transistor-equipped printed circuit module containing 20 single-stage amplifiers for general switch uses. Datex Corp, 1307 S Myrtle Ave, Monrovia, Calif.

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continued on page 115

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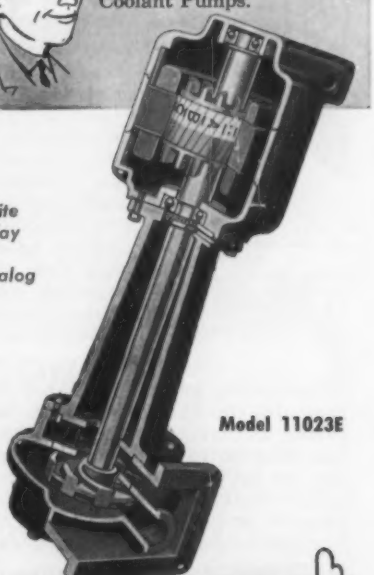

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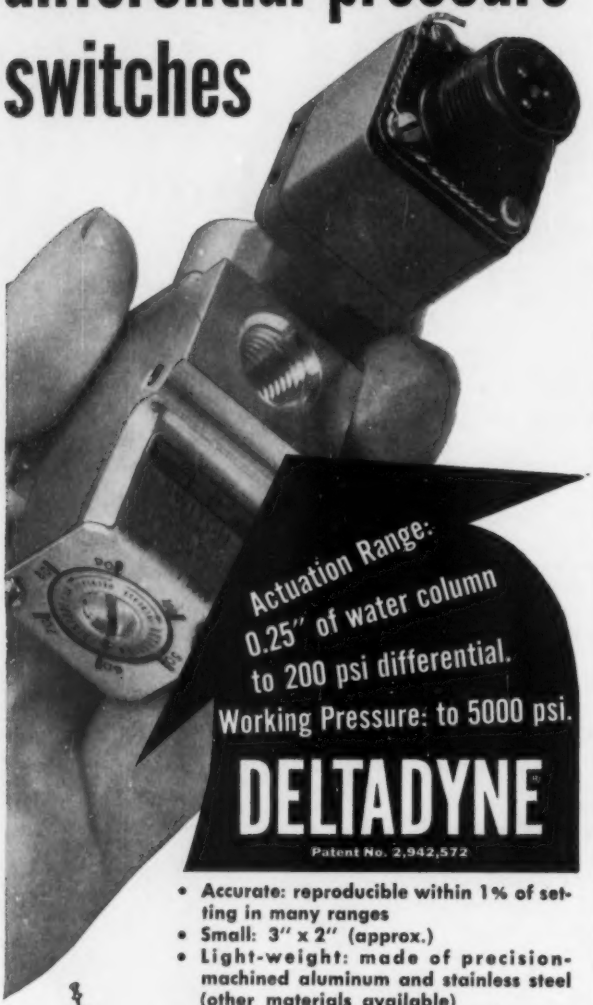

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TEMPERATURE CONTROLS—Condensed catalog MC-203, 8 pp. Design features and specifications are given for 17 types, including differential-expansion models, miniature local controls, fire and overheat detection models, snap-action controls and electronic controllers. Drawings of each are included. Fenwal Inc, Pleasant St, Ashland, Cass.

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MINIATURE LAMPS—Bulletin, 4 pp. Shows 14 in-stock styles with dimensions and electrical characteristics of each. Also describes and illustrates pocket and inspection lights. Welch Allyn Inc, 172 Jordan Rd, Skaneateles Falls, NY.

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DRAFTING FILM—Folder, 4 pp. Contains samples of blue and white, single- and double-matte Mylar polyester film and lists their performance and reproduction characteristics. Arkwight Finishing Div, Arkwright-Interlaken Inc, Fiskeville, RI.

Circle 375 on Reader Service Card

BASIC METAL PRODUCTS—First issue, *News Digest*, external publication published periodically, 8 pp. Applications are described for stainless, high carbon, copper plated and specialty steel wire; decorative, protective and screening grades of perforated and pierced metal; wire cloth; high-carbon spring steels; and machinery for wire handling and metal lithography. National-Standard Co, Niles, Mich.

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LETTERHEAD REQUESTS ONLY

Manufacturers who published following literature asked that requests for copies be made on company letterheads.

INDUSTRIAL GLASSWARE—Bulletin B-91, 8 pp. Discusses and illustrates properties, advantages and applications for 96% silica glasses. Corning Glass Works, Corning, NY.

DC POWER SUPPLIES, TEST INSTRUMENTS—Catalog, 16 pp. Furnishes specifications, including ratings, features, dimensions and weights, as well as photos of over 25 units. Opad Electric Co, 43 Walker St, New York 13.

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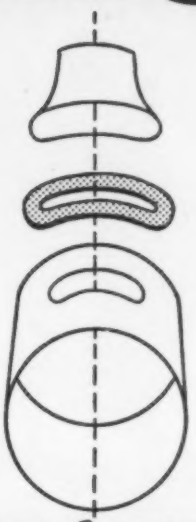

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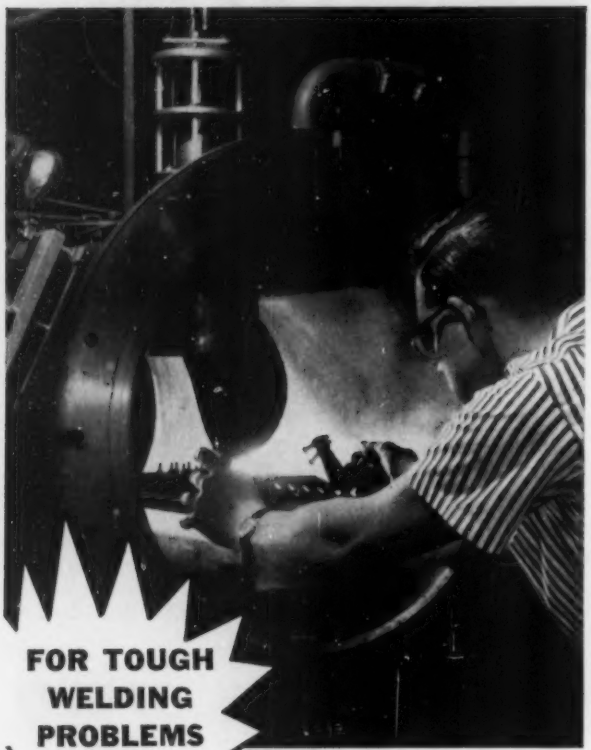

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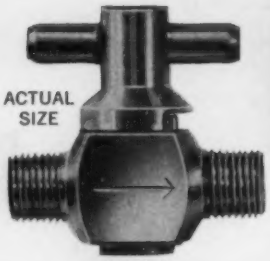

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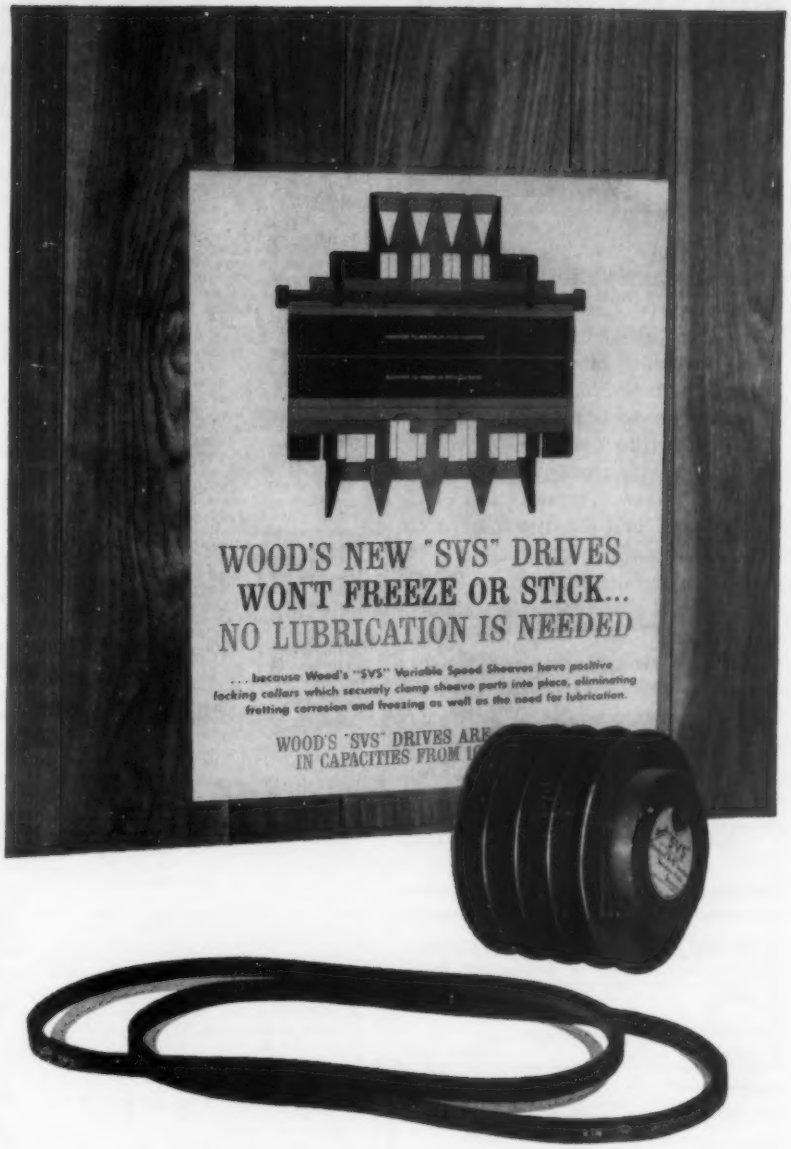
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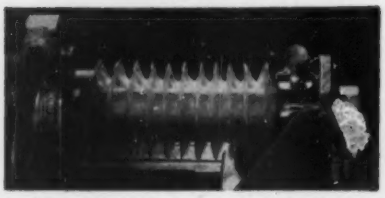

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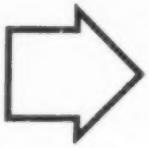

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591—THE RIGHT SOLDER ALLOY
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593—KEEPING THE COMPONENT WARM
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594—Choosing and Specifying Seals
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595—CONSTANT-FORCE SPRINGS
Some are lever-and-spring systems, others are buckled columns, but all offer better isolation of shock and vibration.

596—WHICH INSTRUMENT MOTOR?
Your choice is based on these selection factors: starting torque, response time, speed and speed range.

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A simple method based on two large tables, helps find the best one for your application.

600—SELECTION GUIDE TO HIGH-DAMPING MATERIALS
Basic data on over 50 materials and their use as viscoelastic dampers.

601—PRECISION BALL SCREWS
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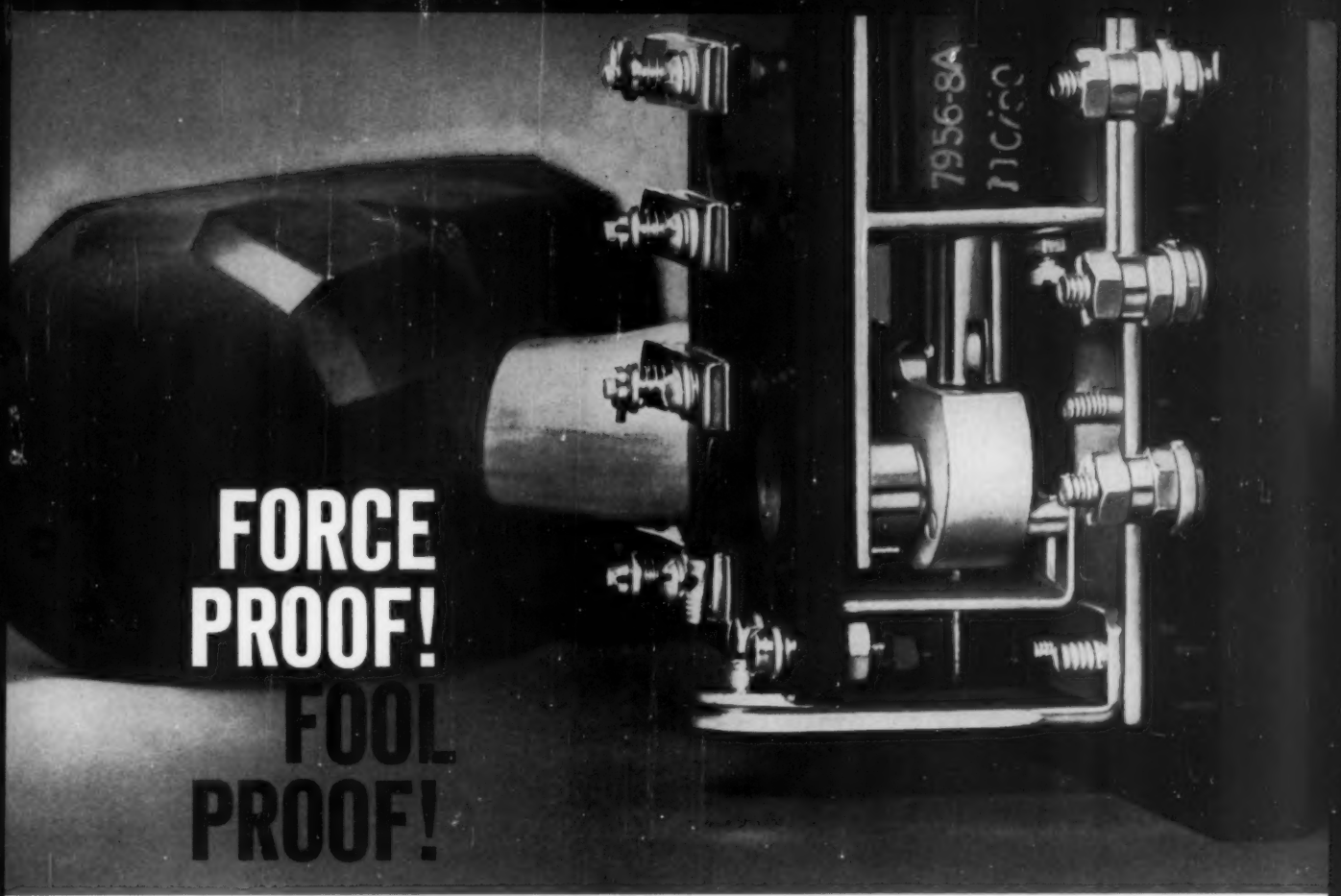
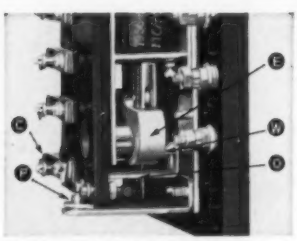
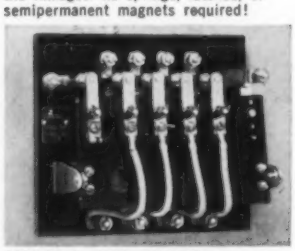




The Unique ASCO Mechanically Held Movement When the solenoid is energized, eccentric cam E is rotated. Weight drive pin W causes movement of operating lever O. Lever O (connected to the contact finger block) rotates on pivot pin P and contacts such as C are opened or closed.

With the solenoid de-energized, the entire mechanism is firmly locked in place by the angular position of the linkages—no springs, latches, or semipermanent magnets required!



ASCO Mechanically Held Relay

even **brute force** will not release the ingenious locking mechanism of **ASCO MECHANICALLY HELD RELAYS**

We don't recommend using it, of course; we just want to emphasize that, short of deliberate destruction of the linkages, only one force can release this powerful locking mechanism and change relay contact position. That force is normal energization of the solenoid coil. Nothing else will alter the angular relation of the linkages, which maintains positive contact pressure despite vibration, gravity, or control circuit failure.

The unique mechanical movement is the heart of any ASCO Mechanically Held Switch or Relay. At the instant of operation, a momentary surge of electrical power retracts the solenoid core to rotate a cam. Momentum carries the cam beyond dead center, and spring-loading completes the core-return stroke to relock the relay in the new position. Linkage action is the same whether contacts are opening or closing; thus the relay is power-driven in both directions.

Design simplicity, typified by the single-solenoid coil mechanism, and rugged, compact construction are characteristic of ASCO Mechanically Held Relays. Complex and less dependable elements such as hooks, latches, semipermanent magnets, or gravity-operated devices are not used. These ASCO relays operate in any position; without AC hum or chatter, and without derating for enclosure.

The extensive ASCO line includes a Mechanically Held Relay to meet your requirements precisely; single pole or in combinations of 24 poles; single or double throw; 10 and 25 amperes; to 250 volts DC, 600 volts AC.

Send for Relay Catalog 57-S4, which shows you how to select the optimum relay for your specific needs.

ASCO Electromagnetic Control

ASCO

DEPENDABLE CONTROL BY Automatic Switch Co. 546 HANOVER RD., FLORHAM PARK, N. J. • FRONTIER 7-4600 • *AUTOMATIC TRANSFER SWITCHES • SOLENOID VALVES • ELECTROMAGNETIC CONTROL*

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The little bearing you almost missed sitting there on top of the big one is too small to fit on your little finger. It's used in the reel of a power mower, and it weighs only 2.6 ounces. The big one is a four-row mill roll-neck bearing, weighing over six tons.

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